

Envis

Wildlife and Protected Areas

Vol. 2, No. 1; June 1999

This issue : INDIAN CROCODILIANS

Bi-annual Bulletin

ISSN 0972-088X



भारतीय वन्यजीव संस्थान
Wildlife Institute of India

The Environment Information System (ENVIS) Centre at Wildlife Institute of India, set up in September 1997, is part of the ENVIS set-up of the Ministry of Environment and Forests, Government of India. It deals with general matters concerning "wildlife" and specifically those related to "protected areas". Its objectives are to :

- * Establish a data bank on information related to wildlife and wildlife protected areas, and thereby build up a repository and dissemination centre for information on wildlife science;
- * Promote national and international cooperation, and exchange of wildlife related information;
- * Provide decision makers at the apex level with information related to conservation and development.

This issue

Envis

Wildlife and Protected Areas
Vol 2, No 1; June 1999

Edited & designed by
Biju Negi

Guest editor
BC Choudhury

Maps by
Navneet Gupta

Acknowledgement
WII National Wildlife Database,
GIS & Library & Documentation
Centre

The contents of the bulletin may be freely used for non-commercial purposes, with acknowledgement.
Citation e.g.: Bustard, Robert H (1999) - Indian Crocodile Conservation Project; ENVIS (*Wildlife & Protected Areas*); Vol 2, No 1; Wildlife Institute of India, Dehra Dun; June 1999; 5-9.

ENVIS bulletin is available on the Internet and may be visited at our website:
www.wii.gov.in

Envis Centre

Wildlife & Protected Areas

Project Leader
SK Mukherjee

Project Coordinator
Dr VB Mathur

Project Co-coordinator
Dr SA Hussain

Project Associates
Dr Debi Prasad Rath
Jayanta Kalita

Advisory Committee
Dr PK Mathur
BC Choudhury
Dr RS Chundawat
Dr Ravi Chellam
Rajesh Thapa
AK Sardar

Wildlife Institute of India
Post Box 18, Chandrabani, Dehra Dun 248 001
Tel - (0135) 640112-115; Fax - (0135) 640117
Email - envis@wii.gov.in
URL - <http://www.wii.gov.in>

Guest Editorial,

"Extinction is forever" - has been a reality for several species in the last couple of centuries. The fear that shrinking habitats, wanton killing of wild species and anthropogenic pressures may cause many of our wild species to be lost forever, has led to an urgency on saving a species from extinction and has forced conservationists to adopt a "species oriented conservation strategy", even though the benefits of an "ecosystem or habitat oriented strategy" may be far greater.

The conservation action for the Indian crocodiles is one such case study. By the mid-1970's, the three species of Indian crocodilians - gharial (*Gavialis gangeticus*), mugger (*Crocodylus palustris*) and saltwater crocodile (*Crocodylus porosus*), were on the verge of extinction. Concerned at this, the Government of India initiated a project to save the crocodilians, adopting an integrated conservation approach, which included an intensive *ex situ* programme to create a large crocodile population rapidly, to be followed by setting up of protected areas where wild population could be reintroduced for *in situ* management. Today, 25 years later, the Indian crocodilians have been brought back from the brink of extinction and there has been successful breeding of the reintroduced crocodilians in the wild in several protected areas.

The project involved UNDP and FAO besides the Ministry of Environment of Forests (MoEF), Government of India, and wildlife

management agencies of the various state governments. The project provided a right mix of management and scientific inputs - a strong research base, a well planned strategy (head-start and grow and release), a network of infra-structural facilities (21 *ex situ* facilities in 12 states) and a strong human resource development component.

This issue of the ENVIS bulletin tries to reconstruct that success story, and place on record the past and present situations to present an updated database on Indian crocodilians at the beginning of the new millennium. Dr HR Bustard, the brain behind this project, shares with us the genesis of the project. This is followed by several state accounts. The various authors, once closely involved in the project, are still involved in the conservation of Indian crocodilians. This issue of ENVIS on Indian crocodilians and their conservation, is our dedication to that pathbreaking initiative taken a quarter of a century ago.

There is a newer question too. Now, with a much enhanced renewable resource base, shouldn't we review our existing policies, bring about a paradigm shift and consider crocodile utilization, as suggested by Romulus Whitaker? Perhaps, yes; maybe, no. A debate, possibly difficult to comprehend at present, but nevertheless required. We hope this issue of ENVIS, inspires such a debate.

BC Choudhury

Mailbag

I agree with you that they are not lesser cats but are less 'known' cats. We hope that this nicely printed document will trigger wildlifers and zoologists to carry out more research work on these interesting carnivores.

Dr Ishwar Prakash
Emeritus Professor of Eminence
Zoological Survey of India
107, Kamla Nehru Nagar,
Chopasni Road, Jodhpur 342 009

*

The second issue of the ENVIS is well documented and on the right time to provide some cues for undertaking serious research on smaller cats of India. These species have been quite neglected so far and deserve urgent consideration for study and conservation measures. The bibliography section of the volume is also quite exhaustive.

Prof HSA Yahya, Chairman,
Centre of Wildlife & Ornithology,
Aligarh Muslim University,
Aligarh 202 002

*

This issue on the "Small cats of India" is excellent, more so the articles written by various authors from all over the country. It is heartening to know that your ENVIS Centre at WII is helping to bring together all researched information collated and available at one place. This will not only be useful to our scientists but also to all lovers of nature and wildlife.

Dr JRB Alfred, Director
Zoological Survey of India
Prani Vigyan Bhavan
'M'-Block, New Alipore
Calcutta 700 053

I find the issue extremely useful and interesting, especially the bibliography which indeed is a herculean task by itself. You are really doing a service to wildlife research leading to conservation.

JJ Dutta, IFS Retd.
B- 222 Shah Pura
Bhopal 462 039

*

In my opinion, it will be better to mention the volume and issue numbers along with year of publication at the top of all pages specially of the first page of each article for ready reference of the readers.

Dr LN Acharjyo
M-71
Housing Board Colony, Barmunda
Bhubaneswar 751 003

*

It would be very helpful if the ENVIS material is simultaneously uploaded on the WII website on the internet, so as to keep updating the information, instead of permitting the data to be outdated in the next couple of years.

Bharat Bhushan, Associate Professor
Environmental Planning
Yeshwantrao Chavan Academy of
Development Administration
Raj Bhawan Complex, Baner Road
Pune

*

The October 98 issue of ENVIS on small cats of India made most interesting reading and does the Institute credit for the quality and range of its contents.

Duleep Matthai, Vice Chairman
Indian Institute of Forest
Management, PB No 357
Bhopal 462 003

The letters have been edited.
- Editor

Contents

Section I : General

1. A Profile of Indian crocodiles <i>LAK Singh</i>	..... 1
2. Indian Crocodile Conservation Project <i>H Robert Bustard</i>	..... 5
3. Significance and Achievements of the Indian Crocodile Conservation Project <i>LAK Singh</i>	..... 10

Section II : Status profiles

1. Status of Gharial and Mugger in Orissa <i>LAK Singh</i>	..... 17
2. Status, Conservation and Future of Saltwater Crocodiles in Orissa <i>SK Kar and SK Patnaik</i>	..... 24
3. Crocodile Conservation in West Bengal <i>Subrato Pal Chowdhary and BC Choudhury</i>	..... 29
4. Status of Crocodiles in Andhra Pradesh <i>BSrinivas, K Vara Prasad and BC Choudhury</i>	..... 33
5. Status of the Saltwater Crocodiles in the in the Andaman Archipelago <i>Harry V Andrews</i>	..... 38
6. Status and Distribution of Mugger Crocodile in Tamil Nadu <i>Harry V Andrews</i>	..... 44
7. Crocodile Conservation in Kerala <i>KGM Pillai</i>	..... 58
8. Crocodile Conservation in Maharashtra : Problems and Prospects <i>MG Gogate</i>	..... 69
9. Status of Mugger and its Conservation Problems in Gujarat <i>V Vijaya Kumar, Raju Vyas and BC Choudhury</i>	..... 62
10. Status of Crocodilians in Protected Areas of Rajasthan <i>KK Sharma, Daulat Singh and BC Choudhury</i>	..... 77
11. Status and Conservation of Crocodiles in Madhya Pradesh : An update <i>RJ Rao</i>	..... 80

Contents *contd.*

12.	Survey of Gharial in National Chambal Sanctuary - 1993-97 <i>RK Sharma</i>	..... 84
13.	Status of Gharial in Ken and Son Gharial Sanctuaries, Madhya Pradesh <i>RK Sharma, PK Choudhury and D Basu</i>	87
14.	Conservation Status of Gharial in Uttar Pradesh <i>Ashok Singh, Ram Lakhan Singh & D Basu</i>	91
15.	Status and Conservation of Gharial in Nepal <i>Tirtha M Maskey</i>	95
 Section III : Ex situ conservation		
1.	Crocodile Breeding in Indian Zoos <i>BC Choudhury</i>	100
2.	Role of Nandan Kanan Zoological Park in the Conservation of Indian Crocodilians <i>LN Acharjyo</i>	104
3.	Crocodile Breeding in Gujarat <i>BR Rawal</i>	109
 Section IV : Future perspective		
1.	Sustainable Use of India's Crocodile Resource <i>R Whitaker</i>	..... 111
 Bibliography 118		
 List of contributors 154		

A Profile of Indian Crocodiles

Dr LAK Singh

THERE ARE 21 SPECIES OF crocodilians distributed in the warm sub-tropical and tropical waters of the world. They are grouped in three families. They are basically similar and differ from one another in minor physical characters such as shape of snout,

arrangement of snouts and dental features, etc. Their distribution and distinguishing features are given in Table I.

In the Indian sub-continent, three species of crocodilians occur - Gharial (*Gavialis gangeticus*), which

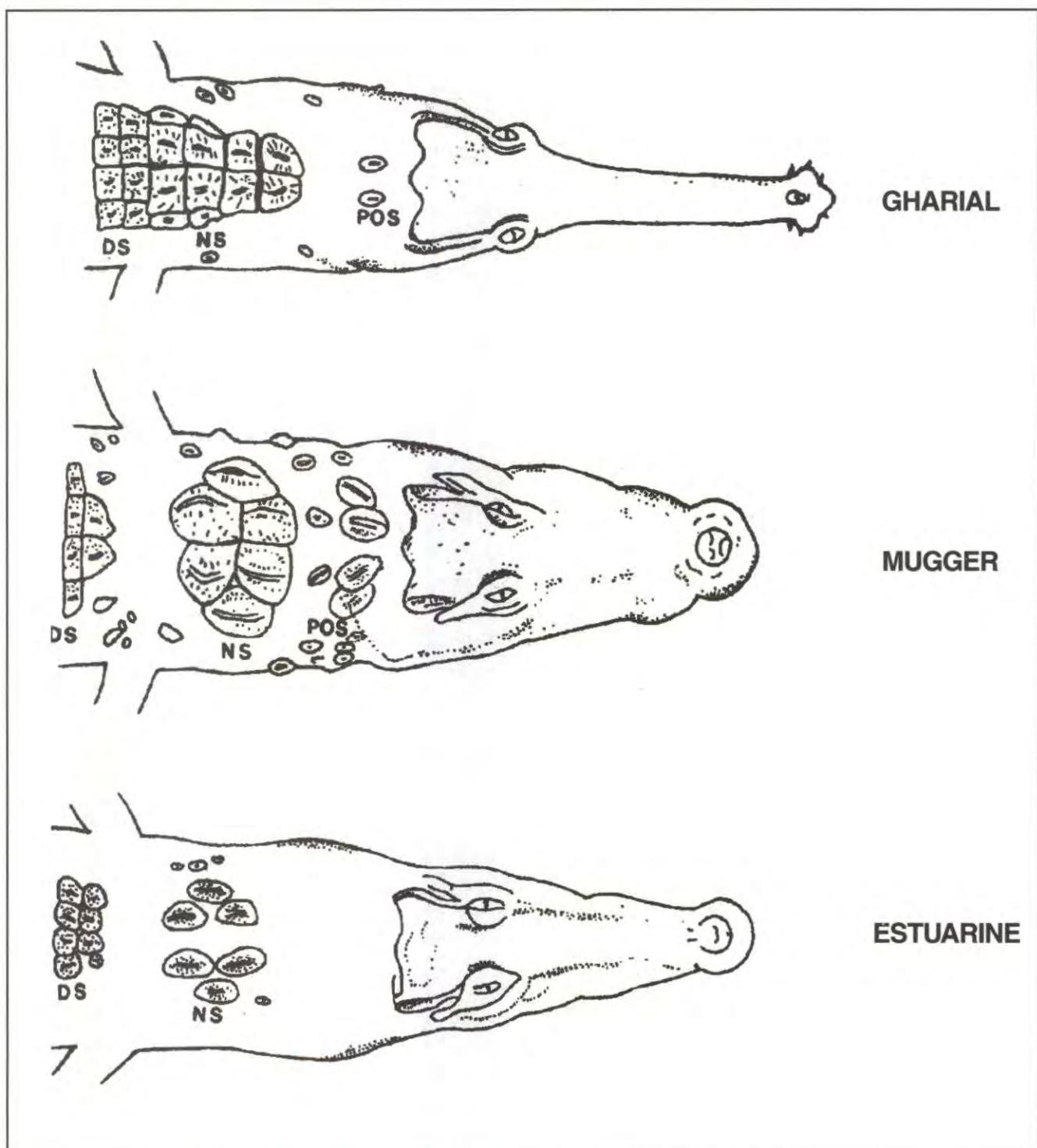
Table I

Character	Family <i>Alligatoridae</i>	Family <i>Crocodilidae</i>	Family <i>Gavialidae</i>
Popular Name	Alligators and Caimans	True crocodiles	Gharial
Head & Snout	More oval than triangular	Broad, triangular head with a short snout	Beak-like extension of the snout
4 th lower tooth (when the mouth is closed)	Not visible from outside	Visible from outside	Visible from outside
Mandibular symphysis (joint between two halves of lower jaw)	Extends to a level less than 23 rd tooth	Extends to a level less than 23 rd tooth	Extends to a level of 23 rd or 24 th tooth
Distribution	S. America, China, USA	Asia, Africa, Australia & Pacific Islands & USA	Asia (India & Nepal)
No. of Genera (No. of species given in brackets)	Alligator(2) Caiman(2) Paleosuchus(1) Melanosuchus (2)	Crocodylus (11) Osteolaemus (1) Tomistoma (1)	<i>Gavialis</i> (1)

Note : Alligators are not found in India; gharial is not an alligator.

belongs to the family Gavialidae, saltwater crocodile (*Crocodylus porosus*) and mugger crocodile (*Crocodylus palustris*) belonging to the family Crocodiidae. (See figure below.)

The distinguishing features and distribution of the sub-species found in the Indian sub-continent is given in Table 2.



POS - Post-occipital scutes;

NS - Nuchal scutes;

DS - Dorsal scutes

Table 2

Important features	Gharial	Mugger	Saltwater crocodile
Popular name	Gharial	Indian mugger	Estuarine crocodile
Incorrect names	Indian Gavial, Indian Alligator	Marsh Crocodile, Swamp crocodile	
Zoological name	<i>Gavialis gangeticus</i>	<i>Crocodylus palustris</i>	<i>Crocodylus porosus</i>
Distribution	<u>India</u> : rivers Chambal, Girwa, Mahanadi and Gangetic system, Brahmaputra. <u>Nepal</u> : Karnali, Kali, Kosi and Narayani rivers. <u>Pakistan</u> : Indus	India, Bangladesh, Nepal and Iran (In Sri Lanka the mugger is similar but in recent years called Ceylonese Mugger, <i>C. palustris kimbula</i> separate from the Indian sub-species, <i>C. palustris</i>)	India to South China, Indonesia, Philippines, Papua New Guinea- N.Australia
Habitat	Perennial and deep rivers	River, marsh, swamp, lake and large pond, any freshwater habitat	Estuarine rivers and creeks where mangroves are present. Migration : Seldom in upstream of rivers, but often in open seas.
Colour - dorsal	Olive with dark cross bands	Ashy to dark or yellowish brown or dark brown cross bands distinct in young.	Young : Yellow with dark blotches. Adult : dark
Colour - ventral	Light yellow to white	White	White
Size : Hatchling (Maximum) on record	34-37 cm 6.6m	25-27 cm 4.0m	30 – 35 cm 7.5m
Snout	Longest, beak-like, sharply demarcated from head.	Short	Longer than mugger, not as long as in gharial.
Post-occipital scutes (see Figure pg2)	May be present	Present in a single row of 4 scutes; all large and distinct	Absent or very indistinct
Nesting season	March/April	Feb./April	May-June
Nest type	In holes on ground (hole nester)	'hole nester'	In a mound of leaves, twigs and soil. (Mound nester)
Nest site/banks	Highly slopy sand-banks with fine sand	Sand-banks, mud-banks	Open areas amid mangroves

Contd.

Important features	Gharial	Mugger	Saltwater crocodile
Egg colour	White	White	White
Egg size (mm. length and breadth)	84x56	75 x 53	80 x 55
No. of eggs per clutch (range) average	10 – 97 30-35	8-45 20.35	10-75 30-35
Incubation period (days) (average)	75-80	55-75	75-80
Growth rates (app. during first 5 years)	45 cm/year	35 cm/year	40 cm/year
Food			
Hatchlings	Fish	Fish, insect meat, worms	As in mugger
Adults	Fish	Molluses, prawn	
Age at sexual maturity (app.years)	Male 15+ years Female 10-12 years	Male : 5-6 years Female : 5 years	Male: 10+ years Female: 8 years
Life span	100 years	70 years	100+years
Breeding life	50 years	50 years	Not known
Temperament	Timid	Aggressive	Aggressive

Note : Adapted and revised from an article published in "Captive Rearing and Management of Crocodile in India" : A field guide; published by Central Crocodile Breeding and Management Training Institute (Government of India), Hyderabad, Andhra Pradesh, August 1982, pp 80.

Indian Crocodile Conservation Project

Dr H Robert Bustard

AS A REPTILE POPULATION ecologist, I became interested in crocodiles in the late 1960's at which time I was in Australia. I wanted to initiate a long-term study on a crocodile species but unfortunately could not find a population which was safe from hunting. I therefore became involved in crocodile conservation in Australia and, as a result of my field work and recommendations, first the Johnston's freshwater crocodile and eventually, the saltwater crocodile were afforded total protection throughout the whole of Australia.

Later, in the UK, I met Sir Peter Scott with the suggestion for IUCN to establish a Crocodile Specialist Group. Sir Peter agreed to this and subsequently, a Group was formed under the chairmanship of Dr Hugh Cott of Cambridge University, who had carried out extensive field work on the Nile crocodile. At the inaugural meeting of this Group in 1972, I accepted personal responsibility for doing something about two very little-known species, the Indian gharial and the Chinese alligator.

Following my return to Australia, I received a letter from UNDP

asking if I could go to India to advise the Government of India on the conservation of the gharial. Originally, the objective was to collect wild gharial and breed them in New Delhi zoo, but I had told FAO in Rome that I was not prepared to do that.

I arrived in India in 1974 and met the then Inspector General of Forests (IGF), KC Lahiri, who approved my plans for conservation in the wild and sent me to gain a bird's eyview of the Indian habitat, returning to Delhi between each trip to report back to him. This proved a marvellous way in which to proceed and Mr Lahiri's liaison with the many State Forest Departments eased my path amazingly.

Mr Lahiri's enthusiastic support at this stage laid the foundations for the project, and at the end of my three months' stay, I was able to write a report setting out the current status of not only the gharial but also of the mugger and the saltwater crocodile. According to my observations, the gharial was reduced to some 60-70 adults spaced widely throughout their former habitat range. In my report, I suggested using the techniques of nest location and hatchery

Formerly, Chief Technical Advisor (GOI/UNDP/FAO Indian Crocodile Conservation Project). He would be pleased to hear from any of his past associates in the project or otherwise involved in crocodile conservation.

incubation of eggs, followed by rearing the young to 1.2m before returning them to specially gazetted and protected sanctuaries. In due course, the Government of India accepted my report and I readily agreed to return to India and implement the project. The Indian Crocodile Conservation Project was set in motion.

I returned in 1975 and initiated the Project at Tikerpada in Satkoshia Gorge sanctuary (Orissa). The Orissa part of the project included saltwater crocodile project at Dangmal in the coastal mangroves of Bhitarkanika. As an academic zoologist, I wanted to pass on my expertise to young Indians, and so collected around me a team of young researchers, both in Orissa and Uttar Pradesh. These researchers, LAK Singh, SK Kar, BC Choudhury, S Chowdhury, among others, have grown to become crocodilian experts in their own right and are members of the IUCN/SSC Crocodile Specialist Group.

Meanwhile, ND Jayal became Joint Secretary (Wildlife) and assisted the project immensely at GOI level. We worked very closely together over a number of years and with his active help many states rapidly adopted the Crocodile Project.

As the project grew, I had to spend increasing time travelling between states and, as such, shifted from New Delhi to Hyderabad, where the GOI set up a Central Crocodile Breeding &

Management Training Institute (CCBMTI), as part of the Project. CCBMTI offered a 9 month Diploma Course to young forest officers in all aspects of crocodile conservation including sanctuary management.

The Project funded a gharial breeding complex in the Nandankanan Zoological Park in Orissa. I designed this complex as a huge pool 9m deep (capacity 180,000 litres) with flowing and recirculating water. The viewing point was only 9m wide on one side of the huge enclosure, the rest having a high wall to provide these shy animals with total protection. The zoo had three adult crocodiles, but the male suffered repeated penile prolapse, and we decided to obtain a large male from Frankfurt Zoo in (then) West Germany rather than capture one from the wild in India. This male reached Nandankanan and despite never having seen another gharial since a baby, mated with the Oriyan females – so we had the world's first captive-breeding of the gharial. Soon there were twice as many eggs being laid there each year as the total number of adult gharial in the entire country at the time of my 1974 survey.

In due course, as part of the Indian Crocodile Conservation Project large protected areas were set up. Outstanding among these were Bhitarkanika Wildlife Sanctuary and Satkoshia Gorge Sanctuary in Orissa and Nagajunasadgar-Srisailam Sanctuary in Andhra Pradesh. This latter is now the

country's largest tiger reserve. The 'crowning glory' for the gharial was the setting up of the Chambal Gharial Sanctuary, spanning the states of UP, MP and Rajasthan, which would not have come into being without the tremendous assistance from SK Seth, the then IGF.

When I left India in 1981, UNDP said that it was the most successful large scale project of FAO/UNDP in India at the time. This was largely possible because of my close working relationships both with GOI and with my counterparts in the states. Without these relationships, involving trust in both directions, the Project could never have developed into a large scale UN assisted project, nor could it ever have achieved its many successes. The Project saved a species from extinction. That is a very substantial achievement.

The current situation

It may be fruitful to briefly review events after a passage of 25 years since project initiation, especially as I carried out the preparatory work leading up to the starting of the Project and was responsible for overseeing its development during initial years. When we began, protection to crocodilians was non-existent, and we had to start from scratch. The success of the Project over the past 18 years since my departure has to be viewed in this context.

The gharial was on the verge of extinction but because of the Crocodile Conservation Project, that eventuality has been averted.

On current information, the gharial seems to be in safe hands. In 1981, I had left behind 2400 artificially reared gharial of which over 1800 have been released in the period up to 1994-95, and monitoring is continuing, though at a reduced level, in the National Chambal Sanctuary where there is a increasing evidence of recruitment of released gharial into the breeding cohort of the population. By 1997-98, the monitoring exercise by MP, Rajasthan and Uttar Pradesh had located over 1200 gharial, and most significantly – over 75 nests in the National Chambal Sanctuary (according to RK Sharma of National Chambal Sanctuary). This is reassuring indeed.

The only comment here is that monitoring is an ongoing business and must not be allowed to be run down. It was lack of quantitative information on its status, and hence absence of any remedial action, that had brought the gharial to the verge of extinction in 1974.

There have been significant gharial gains elsewhere too. The Uttar Pradesh Crocodile project has released 399 gharial in the Girwa river, 257 in the Ramganga, 260 in the Sharda, 255 in the main Ganga, 55 in the Betwa, 45 in the Ghagra and 5 in the Suheli river. This is an immense achievement. Unfortunately, however, no systematic monitoring of these releases is being carried out. This is unsatisfactory – especially in view of the tremendous cost (in both money and time/effort) of producing all these endangered

animals. Hence, I hope that this very considerable achievement can be complemented by extensive and ongoing monitoring surveys and population structure analysis.

Further, in Madhya Pradesh, 35 gharial have been released in the Ken and 177 in the Son river. Up to 1989, the Orissa part of the Project had released 609 gharial in the Satkosha Gorge Sanctuary in the river Mahanadi. However, since no monitoring is taking place, we do not know what the achievements of this country's first gharial conservation project are. Clearly, a most unsatisfactory situation has been allowed to arise which should be speedily remedied. Orissa should realise that, outside of the Gangetic river system, the gharial holds its best chance of long-term survival in the Mahanadi river in Orissa. Monitoring is not a problem in the Mahanadi and should be set in progress immediately.

Turning to the saltwater crocodile, the situation is much less satisfactory. There are only very limited ongoing releases in the Sunderbans (West Bengal) – a huge habitat area ideal for this crocodilian. In Bhitarkanika (Orissa), over 2000 saltwater crocodiles have been released – a very substantial achievement as locating saltwater crocodile nests is very difficult indeed compared to those of gharial or mugger. However, Bhitarkanika requires much enhanced protection and this can only be achieved at the Government of India level. The

whole deltaic mangrove area is much prized agricultural land and Bangladeshis know how to bund the areas to leach out the salt. In my time, on one occasion, we had 10,000 Bangladeshis in the sanctuary cutting down trees and only the assistance at GOI level saw them off. In view of the loss of mangrove areas in southern India, Bhitarkanika must be maintained and its boundaries rigorously enforced.

Finally, the Indian mugger has made a spectacular recovery as anticipated and Binod (BC) Choudhury who has worked extensively on that species, reports that on his last monitoring visit to Hiran lakes (Gir National Park, Gujarat) he counted 300 mugger and located over 50 nests. In Tamil Nadu, he released over 200 mugger in Anamalai Wildlife Sanctuary in 1987-88. In Andhra Pradesh, some 300 mugger had been released into the huge Nagarjunasagar-Srisailam sanctuary declared particularly for the Project, but monitoring data is absent. Other small releases in Andhra Pradesh resulted in quick successful breeding even at sites where mugger no longer occurred (Ethipotnala Falls) and breeding is also taking place in at Manjiri, Pakhal and Kimersani. According to BC Choudhury, released mugger are also breeding in Tadoba National Park and Melghat Tiger Reserve in Maharashtra.

A final message

The future success of the Crocodile Conservation Project will depend on several key factors,

such as :

- 1) The much-needed GOI support to well-conceived state plans for enhanced crocodile conservation – particularly over the long-term.
- 2) The continued – indeed vital – importance and urgency of monitoring in order to collect quantitative information, which is the only way in which a sound scientific assessment of the current status – and hence future requirements – can be obtained. GOI may assist here by emphasising this need at all times.
- 3) Revitalising the active involvement of wildlife managers in crocodile management.

The Wildlife Institute of India may assist in all three of these important inputs by acting as specialist advisers to GOI, by assisting in the planning, initiation, and perhaps implementation of monitoring work and playing a key role in data analysis.

My endeavours all these years ago were strongly oriented towards training. The Wildlife Institute of India is eminently placed to play a vital role here also, specially by reviewing the needs for fresh training initiatives covering all aspects of crocodile and sanctuary management.

A final thought – should the Indian Crocodile Conservation Project be exploiting crocodiles for their

skins? A purely personal view is that it should not. Very definitely India would lose tremendous international esteem by allowing any commercialisation of the gharial. The current status of the saltwater crocodile indicates that it could not withstand any commercialisation. And were the mugger to be opened to commercialisation, it would not be possible for many officers to distinguish between the skins of the various species when they have been made into finished products, e.g. ladies handbags. Furthermore, even if it is suggested that all skins would come from closed crocodile farms (where all the 'product' has been produced from eggs laid in the farm), and how would it be possible to know that these were not being augmented from illegally taken wild stock? I faced this problem with the huge stocks of skins of many reptile species held in Calcutta in 1974. Had they been allowed into trade they could have been continually replaced by freshly-taken wild skins. In my view, in a country with such inventive talent as India there can be no adequate safeguard for the wild population – tags, etc., can easily be faked – were India to be opened up to crocodile farming. India is different, a country with different values, and it should stand firm against commercial exploitation of its wildlife. For the foreseeable future, let the profits come from wildlife tourism, not from the gun or skins/hides/furs.

Significance and achievements of the Indian Crocodile Conservation Project

Dr LAK Singh

THE INDIAN CROCODILE Conservation Project is considered among the more successful of conservation initiatives in the world. It has pulled back the once threatened crocodilians from the brink of extinction and place them on a good path of recovery. The Project has not just produced a large number of crocodiles, but has contributed towards conservation in a number of related fields as well. It is time to highlight these other contributions and redraw attention of all concerned toward a new phase of management, keeping crocodiles as the 'flagship species'.

Management objectives

The broad objectives of activities under crocodile project were as follows :

- a) To protect the remaining population of crocodilians in their natural habitat by creating sanctuaries.
- b) To rebuild natural population quickly through 'grow and release' or 'rear and release' technique involving the following phases of operation :

- (i) collection of eggs from natural nests as soon as these were laid,
- (ii) incubation of these eggs under ideal temperature and humidity maintained in artificial hatcheries,
- (iii) hatching and rearing the young crocodilians in ideal captive-husbandry conditions,
- (iv) marking and releasing young crocodiles in protected areas, and
- (v) assessing the result of release along with protection of the released crocodiles.

c) To promote captive breeding,

d) To take-up research to improve management. Some of the major research activities have been in the following directions.

- (i) Interpretation of various types of data collected during survey and census.
- (ii) Determination of parameters for maximum success in egg collection, egg incubation, hatching, rearing and release, including husbandry aspects on feeding, food conversion and growth.

- (iii) Study of habitat features and population structure.
- (iv) Study of behavioural biology including reproduction, thermo-regulation, feeding, water-orientation, locomotion etc.
- e) To build up a level of trained personnel for better continuity of the project through trainings imparted at project-sites and through the (erstwhile) Central Crocodile Breeding and Management Training Institute, Hyderabad.
- f) To involve the local people in the project intimately through,
 - (i) The development of a strong level of acceptance of the project by the people, by locating the projects in rural areas where people could both see and participate in the entire programme.
 - (ii) Protecting the immediate and long-term interests of fishermen who live within the sanctuaries, and whose livelihood depends on fishing, through, if necessary, providing an alternative source of income that are not detrimental to the conservation aims.
 - (iii) Extending the conservation programme to village-level, commercial crocodile farming, so that people can earn an income from conserving crocodiles and their habitats.

The success of the Crocodile Conservation Project is normally viewed in terms of:

1. The thousands of crocodiles that could be seen in over thirty rearing stations, or over forty sites and zoos where captive breeding takes place,
2. The increased sightings of crocodiles in several out of twenty natural waterbodies where more than seven thousand crocodiles have been restocked - about 4000 gharial (*Gavialis gangeticus*), 1800 mugger (*Crocodylus palustris*) and 1500 salt-water crocodiles (*Crocodylus porosus*).
3. Subsequent natural breeding at some of the restocked locations.

The Crocodile Conservation Project has been among the most successful conservation initiatives taken in the country. In 1984, I had the opportunity of leading a three-member delegation to represent India at the seventh Working Meeting of the IUCN/SSC Crocodile Specialist Group held at Caracas, Venezuela. We presented papers on the "Status of wild crocodilians" and "Ten years review of management". During the discussion hour Prof. Harry Messel from Australia, later the Chairman of the Crocodile Specialist Group, called for over 200 participants to offer a standing ovation to the success of the Indian crocodile conservation project.

In fact, the United Nations Development Programme and the Food and Agriculture

individuals on wildlife and sanctuary management with special reference to crocodilians and riverine sanctuaries. This was carried out through the erstwhile Central Crocodile Breeding and Management Training Institute), Hyderabad, which was later renamed the Crocodile Research Centre of Wildlife Institute of India.

- f) Involvement of local villagers and other public in the activities of the project. This covered individuals like boatmen, crocodile guards, nest-searchers, feed suppliers, husbandry assistants and other technical assistants.
- g) Consultancies and development of wildlife-based relationship with other countries., e.g.
 - (a) Arrangements with Nepal for collection eggs of gharial, demonstration of the maintenance of hatchery and translocation procedure for live hatchlings from Nepal to India.,
 - (b) Assessment for initiation of a project for conservation of gharial in Bhutan.
 - (c) Attending to requests from Pakistan and USA for young gharials.
 - (d) Interactions with Bangladesh for the management of crocodilians there.
 - (e) Training to individuals from Nepal, Sri Lanka and Iran in crocodilian management.
 - (f) Procurement of a male

gharial from the Frankfurt zoo for successful captive breeding at Nandankanan.

Management of terrestrial habitat
The Crocodile Conservation Project has seen the creation of first few wetland sanctuaries of the country under the provision of the Wildlife (Protection) Act, 1972. These crocodile sanctuaries encompass 8,00,000 ha besides the other areas protecting crocodiles covering over 12,00,000 ha. Thus, the total area covered under protected area network for crocodile management is 20,00,000 ha. At the beginning of 1980s, the project boasted thirteen crocodile sanctuaries. Later, several other protected areas highlighted their attention to the management of crocodilians. e.g. Corbett National Park, Dudhwa National Park and Similipal Sanctuary and National Park, all of which are tiger reserves covered under Project Tiger.

Out of the initial list of crocodile sanctuaries, the Nagarjuna Sagar Srisailam Sanctuary (Andhra Pradesh) was later declared a tiger reserve, and the Satkoshia Gorge Sanctuary (Orissa) has been nominated for declaration as either the second tiger reserve or an elephant sanctuary. Satkoshia Gorge Sanctuary and Bhitarkanika Sanctuary have also been proposed for declaration as Biosphere Reserves.

Wildlife research

One of the most striking features of the Crocodile Conservation

Project has been the building up of a base for wildlife research in the country - beginning with the state of Orissa, and followed by Uttar Pradesh and Andhra Pradesh. The project started a trend of involving fulltime research personnel, propagating the idea that successful conservation and research must go hand in hand. Since those initial years of experimentation, the research trends today have certainly gained more significance, yet the research cadre in wildlife conservation projects in the field today survive only in Orissa. In fact, the base for wildlife research is a blind offshoot of the cadered Forest Department. The Government of India has now created a Group 'A' Scientific Service in the Department of Environment, Forests and Wildlife but it does not include any of the fulltime wildlife researchers who began with the Crocodile Conservation Project.

Multiple species management

During the course of field research in wildlife sanctuaries, particularly the Bhitarkanika Wildlife Sanctuary, Satkoshia Gorge Sanctuary and the National Chambal Sanctuary, the ecological roles of other wetland fauna could be highlighted and today we talk of the projects on freshwater turtle, otter, monitor lizard, river dolphin and even the sea turtle.

After the Crocodile Conservation Project took off in Orissa, it was because of surveys along the Bhitarkanika coast and discussions with the Maharaja of Kanika and

Forest Department officials, the turtle resource of the Gahirmatha coast could be highlighted, and later help was even sought to arrange protection to Gairmatha by the Indian Navy. Today, Gahirmatha is known to be the largest rookery of sea turtles. In view of this Orissa had produced a project document for an integrated scheme on conservation of the saltwater crocodile and the marine turtle in Bhitarkanika.

Project Tiger compared

The Crocodile Conservation Project compares well with the universally acclaimed Project Tiger. Project Tiger involves protection of the sites of conservation and takes an *in situ* approach, while the project on crocodiles involves both *in situ* and *ex situ* approaches, offering protection to habitat in its totality and also *ex situ* management of the eggs and animals to produce a large number of the animals and improve their chances of survival.

If it is argued that the latter approach was also to demonstrate the 'farming' potentialities of crocodiles, that too again is well ahead of time into which India will step-in in near future. As the trend goes, "human elements" cannot be kept off the wilderness areas and as such, the "use-component" cannot be totally checked. In such a case, crocodiles will stand in the fore-front of sustainable yield programmes of wildlife resource management, whenever the concept is legalised.

The future

As said earlier, crocodile conservation is a highly successful story in terms of setting a trend in wetland faunal management, wildlife research and training. Today, the population of all Indian crocodilians along with their ecological associates continue to survive in a relatively healthier state. But the urgent need is to reassess their status in the wild and draw up an action plan that can maintain the effort and momentum of the project and sustain it over a long period of time ahead.

Accordingly the project today needs to -

- (a) immediately conduct an extensive survey in all crocodile habitats;
- (b) keep alive some good rearing stations;
- (c) locate alternative habitats for gharial;
- (d) attend to 'problem crocodile' calls more effectively;
- (e) build up a base to gear villagers towards a possible village farming operation for the saltwater crocodiles; and
- (f) project crocodile sanctuaries as wetland areas of multiple-species management.

Status of Gharial and Mugger in Orissa

Dr LAK Singh

THE PRESENT STATUS OF gharial and mugger in Orissa and, in fact, all over the country, is not completely known because of lack of systematic coordination either at the national or state level during the last one decade. Data is available only in fragments and that too from a few places. However, at most of these places, the efforts seem to have been to keep alive the technique of crocodilian rearing and management that was so well generated under Indian conditions, with technical and financial collaboration from FAO/UNDP mostly during the first ten years following 1974.

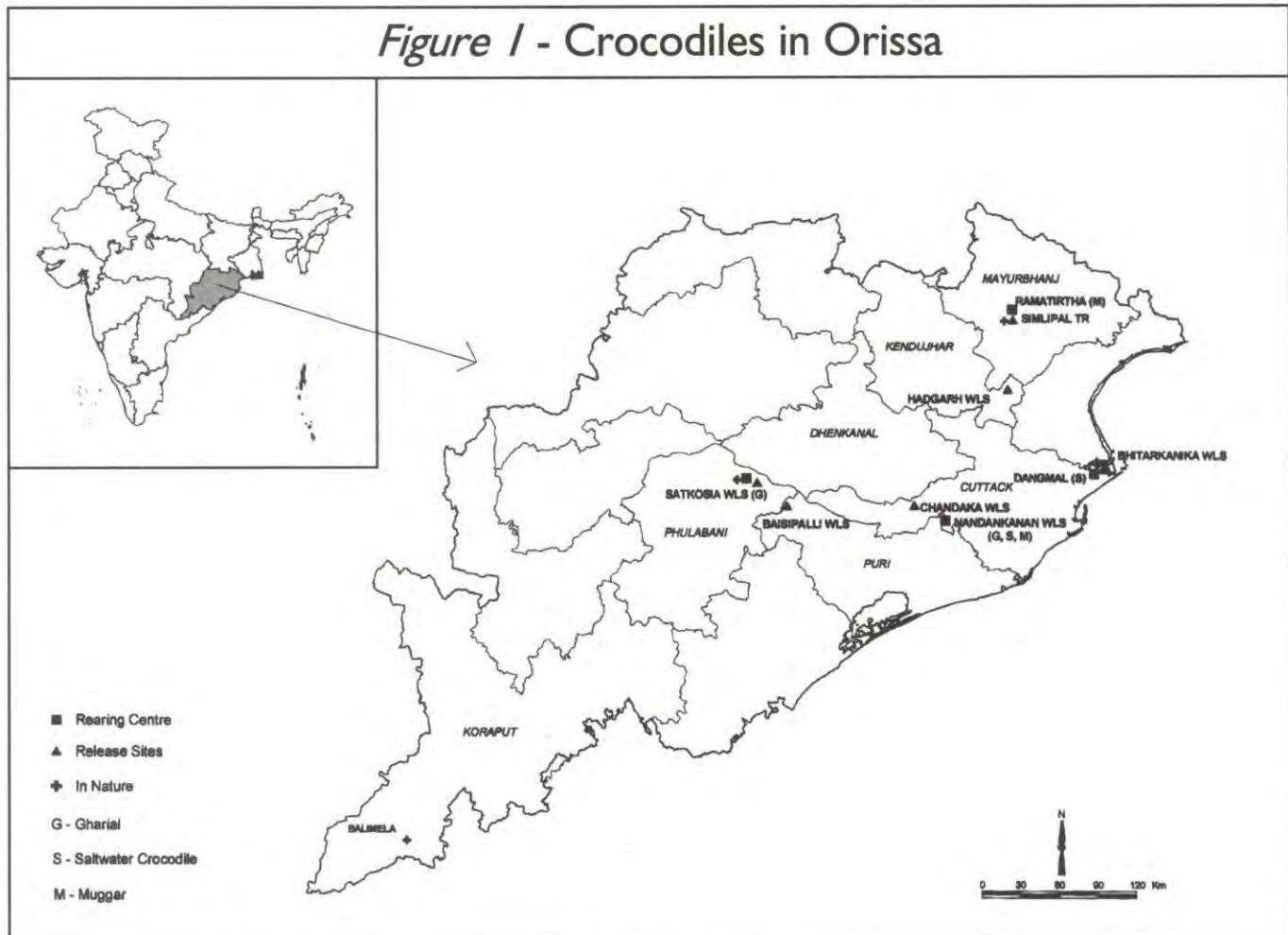
The present sorry state of affairs has resulted from a combined effect of the following happenings.

- a) Production of a large number of captive stock without adequate suitable places for release.
- b) Growth of human population leading to reduction in undisturbed habitats for released crocodilians back in the wild.
- c) Unplanned financial assistance from Government of India.
- d) Closure of continued international assistance through FAO/UNDP.

- e) General disapproval of the idea of commercial utilization.
- f) Absence of a national-level monitoring institution after closure of the erstwhile Central Crocodile Breeding and Management Training Institute and its later incarnation as Crocodile Research Centre of Wildlife Institute of India at Hyderabad.

Orissa is the only state in the country where all the three Indian species of crocodilians - gharial (*Gavialis gangeticus*), mugger (*Crocodylus palustris*) and saltwater crocodile (*Crocodylus porosus*) are found in their natural habitats. It was in this state that the Indian Crocodile Project was launched first and researchers worked full-time to generate a database to assist conservation.

Starting in 1975, the Orissa state programme developed three research and conservation units at Tikarpada, Dangmal and Ramatirtha for captive rearing of the gharial, estuarine crocodile and the mugger respectively. It included the management of three crocodilian sanctuaries at Satkoshia Gorge, Bhitaranika and Hadgarh, and management of mugger crocodiles in the Simlipal

Figure 1 - Crocodiles in Orissa

Tiger Reserve. Apart from these, captive breeding facilities were developed for all the three species at Nandankanan.

THE GHARIAL IN ORISSA

The gharial once inhabited all the major river systems of Orissa, namely, the Mahanadi, Brahmani and Baitarani. Their occurrence in Sileru and Saberi, the tributaries of the Godavari system have also been recorded. However, by 1975, only Mahanadi was left with some adults and juvenile gharial.

Realising that because of heavy loss of eggs and hatchlings, the recruitment of crocodilians was low in nature, the 'rear and release' technique was adopted for their

conservation. And Satkoshia Gorge Sanctuary was especially established to augment the protection measures initiated for the gharial. .

The gharial project at Tikarpada was the first of its kind in the country. Here, initially, the gharial eggs or hatchlings were brought from Nepal and later from the National Chambal Sanctuary.

The 'rear and release' technique involved a five-steps operation :

- 1) Collection of eggs laid in wild, to reduce predation of eggs;
- 2) Incubation of eggs under hatchery-conditions with

proper supervision, to reduce embryonic mortalities and produce more 'fit' hatchlings;

- 3) Rearing of hatchlings under high standards of husbandry, to achieve higher juvenile-survival;
- 4) Releasing young gharial when about 1.2m body length at appropriate places, allowing them sufficient time to settle down in the habitat before the monsoon; and
- 5) Monitoring of the released gharial to ascertain the efficacy of the conservation programme.

Some of the significant management actions taken up with an intention to manage gharial as the 'flagship species' in the Mahanadi were as follows :

Satkoshia Gorge Sanctuary

A 30km length of the river Mahanadi, encompassing the once famous habitat of gharial, the Satkoshia gorge and the adjoining forests on the northern and southern sides, were gazetted as the Satkoshia Gorge Sanctuary in May 1976, with a total area of 795.5sq.km. In November 1981, another 168.4sq.km, covering the Baisipalli Sanctuary in its south were added to it. In 1989, an area of 384sq.km. was identified as the core area of the sanctuary. Later, the entire area of the Satkoshia Gorge-Baisipalli Sanctuary was placed under the administrative

control of the Satkoshia Wildlife Division for some years. The experiment ended in 1993-94 and the areas were transferred back to the territorial forest divisions. The sanctuary is now under the jurisdiction of five Forest Divisions - Angul, Athgarh and Athmalik in the north, and Boudh and Nayagarh in the south. Efforts are afoot to revive the separate status of the Satkoshia Gorge Sanctuary either under Project Tiger or Project Elephant.

However, looking at the 'non-survival of gharial in Mahanadi', it has been concluded that the riverine stretch of the sanctuary has proved to be inadequate for gharial.

Induction of gharial guards

The gharial project has served as a means to involve public into the conservation programme. The induction of riverside fishermen as Gharial Guards and other educated youth in the captive rearing programmes have helped to demonstrate the employment opportunity offered by the conservation scheme. It has also helped to earn the goodwill of the public.

Bamboo rafting

Rafting of bamboo by the Titaghur Paper Mill was one of the major factors adversely coinciding with the breeding season of the gharial. Fortunately, this activity has ceased since 1987 although it was too late to offer the benefits in the first phase of the conservation programme.

Fishing regulation

As a major step to regulate fishing in Mahanadi, permits are being issued to authorised fishermen. Fishing camps on the riverbanks have been banned. However, the entire practice of fishing in the rivers needs to be looked at afresh, and open cast fishing replaced with inland captive fish-farming to engage the fishermen who are totally dependent on river-fishing but finding it increasingly less rewarding.

Permit for navigation

Boats using the river stretch within the sanctuary need to have permits and thus a record of their movement is maintained to evaluate navigation activities. However, this needs to be replaced with other easier and quicker modes of transport outside the water surface.

Non-survival of gharial in Mahanadi As part of the crocodile conservation programme, over 700 juvenile gharial have been released in the Mahanadi. These juveniles have originated from the rivers Narayani and Kali in Nepal, and the National Chambal Sanctuary and the captive breeding programme in Nandankanan in India, supported by a male received from the Frankfurt zoo. However, the resighting of gharial after release has been as low as 5%. A host of factors are responsible for, first, the near-extinction of the natural population of gharial in Mahanadi, and second, the non-survival of most juveniles in the desired stretches of the river.

Geographic isolation of the population of gharial in Mahanadi may have occurred over geologic time, followed by localization of the main breeding populations in recent historical times. Later, isolation of the populations appears to have led the populations to suffer gradual erosion in its gene-pool because of the decreasing number of breeding individuals. The chain of events from geologic through historic to recent times may have led gharials in Mahanadi to a stage of near-extinction.

Moreover, since *Gavialis gangeticus* is the oldest crocodilian and the sole surviving member of an evolutionary line, it may be that the concept of 'species senescence' is operating on the gharial and that this "antique crocodilian" is more sensitive to the environmental changes. The species continues to survive where such changes have been relatively low (e.g. National Chambal Sanctuary). Therefore, when the genetic make-up of the gharial species has eroded because of 'species senescence', the released gharial (in Mahanadi) require a very favourable, 'non-struggling' environment to settle and flourish. But in the face certain traditional practices of use of the river and the rising demographic pressure, the released juveniles have not received such an ideal and favourable environmental setup in Mahanadi. It may not be out of place to mention that even in Chambal, Girwa, Son and Ken sanctuaries all juvenile gharial rehabilitated under the

conservation programme do not survive.

Besides, the Satkoshia Gorge of Mahanadi appears to be an 'adult habitat', while the 'juvenile habitats' available outside the Gorge, between Larasara and Mundali, are under heavy human use. Man-made pressures and inadequate use of these habitats for restocking may have prevented the juveniles to settle in Mahanadi. But the use of the place without providing adequate protection could prove counter-productive.

Gharial also faces a natural competition from the 'better fit' muggers. Interference by human and conservation mistakes committed by releasing mugger in the habitats of gharial can only help further the mugger species push the gharial out of its niche.

Finally, the most deterministic forces for the present status of gharial in Orissa have their origin as the multi-faceted 'human factor'. The mode of fishing and the habits of people of Satkoshia Gorge Sanctuary are dominated by boating activities which are incompatible with conditions required for a sanctuary for gharials.

The narrow width of the river in the Satkoshia Gorge and the absence of mid-water islands worsen the situation for gharial. Therefore, apart from evolutionary and biological reasons, the incompatible human activities, centered around boating and rafting are considered as major

reasons for the non-survival of gharial in the narrow Satkoshia Gorge of Mahanadi. (See Box 1 below)

The mugger in Orissa

The distribution of mugger is now limited to rivers of Similipal, Balimela reservoir, the Mahanadi river system and isolated freshwater swamps in southern Orissa. Major conservation work has been in progress in Similipal since 1979. Results of a survey conducted in November-December 1979 indicated that the mugger had virtually become extinct in Similipal, possibly because of (i) fishing by nylon nets and explosives, (ii) use of insecticides with an intention to control malaria, (iii) fire in the riverbanks forming nesting sites, and (iv) natural effects of predation and exhumation by wildboars, monitor lizards and mongoose, etc. There were no indication that the Khadias which are a digger-cum-gatherer tribe collected mugger eggs too.

The mugger conservation project in Similipal began with an initial stock of muggers brought from Tamil Nadu. The objectives were to release mugger in Similipal and maintain a breeding stock in captivity to produce juveniles for future releases in Similipal and elsewhere. From 1984 onwards the juveniles have been captive-bred at Ramatirtha near Jashipur.

The release of juvenile mugger in the river systems of Similipal in 1981-1998 have been as follows:

Box I Summary of some of the measures proposed		
(I) Declaration of Mahanadi Sanctuary	Area: (Including Satkoshia Gorge Larasara to Mundali along the main river; one km distance of main tributaries, 500m wide along each bank.	Area : Larasara-Sonepur
(II) Future release of gharial in river Mahanadi	Size : 1.2m and over Number : Groups of thirty Time : November each year Monitoring : By using radio-tracking method	
(III) Release of gharial in river Brahmani	Carry out a survey of the river including Rengali Dam and Samal Barrage	
(IV) Compatible and sustainable utilisation of Fish resource	(1) Promote pisciculture farms (2) For 10 yrs stop collection of fish spawn except for bio-technological research (3) Allow night-time prawn capture only from tributaries, for limited periods (4) Purchase all nylon set nets from fishermen	
(V) Regulation of navigation in Mahanadi Sanctuary	(1) Initially for ten years ban all navigations except those for environmental protections (2) Promote a colony of potter at Narasinghpur (3) Replace the motor-boat at Tikarpada with one which is environmentally compatible	

<u>River System</u>	<u>Nos. Released</u>
B.Balanga	176
Khairi	127
West Deo	287
East Deo	42
Khadkei	18
<u>Total</u>	<u>650</u>

The monitoring results of 1999 indicate that over 10% of the released stock are readily traceable. This is better than the natural rates of recruitment and

survival. However, since the management of the sanctuary is still being affected by human dimensions in various forms, it is felt that the release of mugger juveniles should be continued at a modest rate of 30-40 juveniles a year until more number of adults get settled and communal nesting becomes pronounced.

Apart from the above, muggers have also been released in

Satkoshia Gorge Sanctuary and Chandaka Elephant Reserve. Hadgarh Sanctuary, earlier earmarked for management of mugger crocodiles, is being planned to be managed under Project Elephant, which will simultaneously provide attention to the wetland habitat.

The overall status of mugger in Orissa is that the species is now

seen in habitats where there were none or were rare, but breeding in the wild is not remarkable. Captive stocks are available at Ramatirtha, Tikerpada and Nandankanan, which serve mainly for tourism and educational purposes but also ensure that the indigenously developed technique of captive management continues to survive at these locations.

Status, Conservation and Future of Saltwater Crocodiles in Orissa

SKKar and SKPatnaik

WITH THE INITIATION OF Government of India/FAO/UNDP Crocodile Conservation Project, the Forest Department, Government of Orissa implemented a scheme for conservation of saltwater or estuarine crocodiles (*Crocodylus porosus*) along with two other crocodilian gharial (*Gavialis gangeticus*) and mugger crocodile (*Crocodylus palustris*). A Saltwater Crocodile Research and Conservation Centre was established at Dangmal in the heart of the Bhitarkanika Wildlife Sanctuary with the purpose of quickly multiplying the population using the 'rear and release' technique to save this endangered reptile.

Objective

The prime objectives of the saltwater crocodiles were (Kanungo, 1976) :

1. To conserve the endangered saltwater crocodile species by providing adequate protection to its threatened habitat;
2. To quickly build up its depleted wild population through large scale 'rear and release' programme; and
3. To conduct research on the ecology and biology of saltwater crocodiles.

4. Later, to exploit the species (surplus population) through large-scale captive farming (during the second phase of the project).

During last 24 years, maximum emphasis has been given to collection of eggs laid in wild from Bhitarkanika Sanctuary for safe hatchery incubation by simulating natural conditions, rearing the young ones with sound husbandry conditions and releasing juvenile crocodiles (over 1.0m in length) in the river system of the sanctuary, monitoring the released crocodiles, collecting relevant data on wild and captive populations besides study on socio-economic aspects of the local inhabitants and 'man and crocodile' conflict etc. (Bustard, 1975; Daniel and Hussain, 1974; Kar 1978 & 1981).

Rear and release programme

Due to successful implementation of this Conservation Research Management Programme, the depleted population of saltwater crocodiles have now gradually built up through large scale release of captive reared crocodiles into the wild as well as providing adequate protection to the mangrove habitat.

During the last 24 years, 5274 eggs of *C. porosus* have been collected from the forest blocks of the sanctuary, out of which 2695 hatchling hatched (51.1%) and 2488 crocodiles survived (92.4%) at the Saltwater Crocodile Research and Conservation Centre, Dangmal. At present, about 300 crocodiles including one partially white (locally known as 'Sankhua') female crocodile are being reared in captivity there.

Since the 1990s, the rear and release programme of *C. porosus* have been taken up on a very modest scale to keep alive husbandry and research techniques. At present over 40 clutches of eggs (more than 40 females are laying eggs including a few released crocodiles) are available inside the sanctuary but hardly a clutch or two (about 100 eggs) have been collected for project hatchery incubation.

Restocking of crocodiles

The wild population of saltwater crocodiles in Bhitarkanika was depleted to such an extent that the only way to restock was through release of captive reared young crocodiles (1.0m size). The first releases back into the wild of 15 individuals took place in February to May 77 (Kar & Bustard, 1989), then 80 crocodiles during 1978 (Kar and Bustard, 1991) and this followed by subsequent releases of about 2000 young crocodiles in phased manner into the river systems of Bhitarkanika Sanctuary (Choudhary et al, 1996).

The average density of saltwater

crocodiles (other than hatchlings) in Bhitarkanika was 0.87 individuals/km (Kar and Bustard, 1989 & 1991) during 1976-77 census (before release) but 1998 census indicated 5.0 individuals/km.

Census of crocodile population

To ascertain the status of the crocodile population, the whole sanctuary including the peripheral areas have been surveyed covering all the river and creek systems during the peak winter months (December-January) regularly. According to the 1976-77 census (prior to release) indicated that there were 29 adults, six sub-adults and 61 juveniles in the entire Bhitarkanika sanctuary. In the last census in December 1998, a total of 672 crocodiles were counted, which included 150 hatchlings, 146 yearlings, 160 juveniles, 144 sub-adults and 72 adults (10 ft +).

The released crocodiles have been monitored regularly to (a) assess their survival in nature; (b) study the habitat preference; and (c) record their movement, home range, seasonal migration and growth rate etc.

These annual operations indicate a close correlation between crocodile numbers (adults, sub-adults and juveniles) and the ecological health of the mangrove ecosystem. Considering the released population and annual natural recruitment, the survival of juveniles and sub-adults are not much encouraging due to several adverse factors, the major being biotic interference.

Crocodile attacks on humans

The saltwater crocodile is widely stated to be most dangerous species of crocodilian from the human standpoint (Neill, 1977). However, in our experience, instances of man-eating have been greatly exaggerated (Bustard and Kar, 1982; Kar & Bustard, 1983). There have been 35 instances of attacks on human beings in the last 24 years (1975-76 to 1997-98) which includes 75% males. In 34 cases, large males of over 16 ft were responsible and in only one instance, a crocodile, 9 ft long, was involved for the killing of a human being. In 1988, within a span of few days, one crocodile of about 19 ft length was responsible for killing three persons who were fishing illegally at night in one of the creeks of the sanctuary. Later, the crocodile was netted and killed by the poachers (Kar & Padhi, 1992).

In Bhitarkanika Wildlife Sanctuary, all ingredients for human attack exist, particularly the frequent human intrusion into the crocodile habitat illegally and crocodile population in the sanctuary including a couple of very large males (Kar & Bustard, 1989).

Livestock crocodile conflict

Instances of attack on domestic livestock by saltwater crocodiles have been recorded from August 1975 to March 1998 inclusive. In all, 40 attacks involving buffaloes, bullocks, cows, calves and goats were recorded. All attacks/deaths reported were by large males of above 16 ft length. High-tide is usually essential to bring the

crocodiles lying in wait in the water within striking distance of the animals grazing on the riverbank. 90% of the attacks occurred during the rainy season wherein riverbanks were flooded by high-tide/flood. The attacks all occurred at locations where the natural mangrove cover has been destroyed by the people. Ideally crocodiles and cattle should be separated and there should be no grazing in sanctuaries.

The solution lies in maintaining a strip of undisturbed mangrove forests, at least 100m wide all along river/creek banks adjacent to cultivated land inside the sanctuary.

Public involvement

The crocodile conservation and research project not only ensures the conservation of this species but also, provides suitable job opportunities for a number of local inhabitants in various ways such as field attendant, research foresters, crocodile/sanctuary guards, husbandry attendants, tourist guides, fish suppliers for captive reared crocodiles and other such developmental and management work from time to time.

Research priority

(a) Reintroduction of the young saltwater crocodiles in the Mahananadi estuary system and to study their survival movement and dispersal etc.,

(b) Study on 'man-crocodile' conflict.

(c) Study on the carrying capacity

of *Crocodylus porosus* in the Bhitarkanika Wildlife Sanctuary.

(d) Habitat features and population structure.

(e) Interpretations of various types of data collected during survey and census.

Recommendations

(1) Encroachment on the mangrove habitat for rehabilitation, agriculture and prawn culture, etc. should be completely banned.

(2) Use of gill nets in the rivers, creeks and creeklets throughout the sanctuary should be strictly prohibited.

(3) Degraded mangrove forest should be restored by plantation and rigid protection. Moreover, at least 100m wide a strip of mangrove forest should be created all along rivers/creeks adjacent to cultivated land inside the sanctuary.

(4) Measures may be taken to eliminate man-crocodile conflict.

(5) Large-scale eco-development programme should be implemented on the outskirts of the sanctuary to minimize/reduce the pressure on mangrove forest by local people.

(6) Studies on the ecology of estuarine/saltwater crocodiles should be continued,

considering the existing gap in the knowledge regarding various aspects of ecology of the species in Bhitarkanika and other distributional range in Orissa as well as in the entire country.

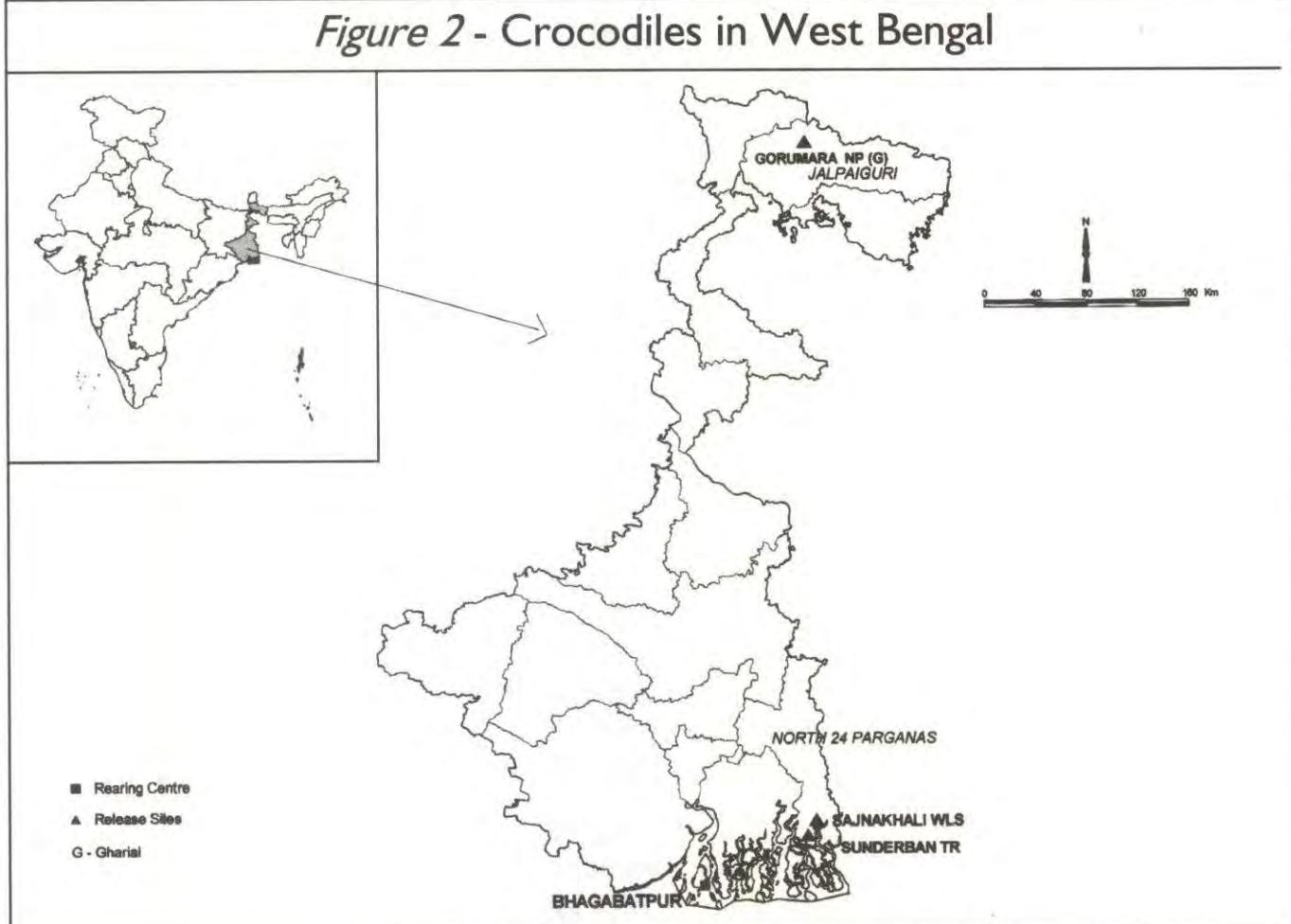
(7) Education and awareness programmes should be created among the local inhabitants to change their hostile attitude towards conservation of saltwater crocodiles and other wildlife species along with the threatened mangrove ecosystem.

Conclusion

Despite best efforts of 'rearing and rehabilitating' this species, the future cannot be bright unless the sanctuary and the crocodiles are adequately protected and until large number of juvenile saltwater crocodiles attain breeding size and commence breeding in the wild. Besides, the deltaic areas of the Mahanadi river system, which was in recent past an ideal habitat for *C.porus* (at present not a single crocodile is seen) should be restored and crocodiles should be rehabilitated into suitable protected creek systems. A long-term research programme on identified parameters should be taken up in this unique crocodile habitat with the funding support from Government of India.

References

BUSTARD, HR (1974) - India : A preliminary survey on prospects of crocodile farming; FAO Rome (F.O.IND/71/033), pp 1-50.

Figure 2 - Crocodiles in West Bengal

Release of Captive Reared Saltwater Crocodile

As early as 1997, the project started releasing 1.2 - 1.5^m sized saltwater crocodiles into the wild. Till 1998, over 332 saltwater crocodiles have been released into the Sunderban mangroves. Details of year-wise release and their location of release is given in Table 2 below.

Monitoring of released crocodiles and rescue of strayed crocodiles

In the Sunderban mangroves and the tiger reserve, monitoring of crocodiles is a difficult task because the mudflats where crocodiles bask often get inundated. Also, because of the large-scale human population density in the state and

the socio-economic dependency of people on wetland habitats, there is a problem of reintroduction of crocodilians in natural unprotected wetland sites. Every year, the staff of the state forest department's wildlife wing captures yearlings and juveniles from different localities of Sunderban (See Table 3).

While some of the juveniles being caught in the different localities are those released by the as part of the project, the smaller hatchling and yearlings are all considered to be resultant offsprings of those now breeding in the wild. Captive releases have been continuing since 1979 with three-year old crocodiles and it is

Table 1
Details of egg-collection and hatching of saltwater crocodiles
at Bhagabatpur Crocodile Centre, West Bengal

Year	Eggs collected	Hatched	Mortality
1977-78	72	45	2
1978-79	74	20	10
1979-80	73	14	13
1980-81	43	2	-
1981-82	44	41	2
1982-83	41	-	2
1983-84	45	40	1
1984-85	51	47	11
1985-86	-	-	-
1986-87	72	17	0
1987-88	28	24	2
1989-90	107	31	3
1990-91	105	38	2
1991-92	85	65	6
<i>Total</i>	873	417	55

Table 2
Year-wise account of release of crocodiles in different rivers of Sunderban reared
in Bhagabatpur Crocodile Project

Year	Male	Female	Annual No.	Cumulative Sum	Place of Release
1979	13	27	40	40	Nabanka, Panchmukhani, Matla, Gosaba, Pirkhali-1 & 2, Lothian
1982	3	22	25	65	Netidhopani, Gana, Chamta.
1983	6	12	18	83	Netidhopani, Matla, Chandkhali
1984	6	15	21	104	Netishopani,Chamta-2, Bhagmara
1986	1	29	30	134	NetidhopaniChotamamta, Arbasi
1987	17	13	30	164	Pirkhali-1, Chota Hardi, Chamta-4, Haldibari, Burir Dabri, Chamta
1989	1	12	13	204	Netidhopani,Panchmikhani, Chamta - 4.
1991	11	9	20	224	Chamta-2 & 4, Netudhopani
1992	7	8	15	239	Matla-2, SuryaMukhani Canal
1993	7	4	15	254	Khawa Gula, Narayantala, Tarakhal (Panchmukhani)
1994	3	18	21	275	Chota Haldi Camp-2, Chandkhali Camp-4
1995	3	12	14	289	Lijukhali, Matla-1, Netidhopani
1996	3	12	15	304	Netidhopani Camp-2, Chamta Camp-2
1997	5	8	13	317	Chamta Camp-2, Chandkhali Camp-2
1998	4	11	15	332*	Chandkhali-2, Chamta-6

Table 3 Saltwater crocodile yearlings rescued from nature	
Year	Number
1976-77	1
1977-78	8
1978-79	6
1979-80	3
1980-81	30 (Released & Rescued)
1981-82	1
1985-86	9
1986-87	-
1987-88	8
1988-89	19
1990-91	6
Total	91

expected that many of them may have recruited into the breeding cohort. However, without a full scale scientific monitoring and enquiry, it will be difficult to come to such conclusions.

The future of saltwater crocodile programme will depend on their protection and management within protected areas, a proper long-term strategy of monitoring the survivors and the well being of the released stock.

Reintroduction of gharial

It may be mentioned that encouraged by the historical accounts of presence of gharial in Thorsa and Teesta rivers, the West Bengal forest department has contemplated reintroduction of gharial into the wild. An experimental release of gharial into semi-wild situation has been conducted in Gorumara wildlife sanctuary.

References

BUSTARD HR (1980) - Indian most endangered crocodile wild he saltwater crocodile survive ? Makara. 2(1) p 2-3.

BUSTARD HR AND BC CHOUDHARY BC (1981) -- Conservation future of the saltwater crocodile (*Crocodylus porosus*) in India J.B.N.H. 77 (2) p 201-214.

SMITH. MA (1935) - The fauna of British India including Ceylon and Burma. *Reptilian and amphibian Vol. 2 Sauria*. London : Taylor Francis.

Status of Crocodiles in Andhra Pradesh

B Srinivas, K Vara Prasad
and BC Choudhury

THE STATE OF ANDHRA PRADESH historically supported populations of mugger (*Crocodylus palustris*) and saltwater crocodiles (*C. porosus*). However, the saltwater crocodile became extinct in the state by the late 1940's and the mugger population had been much reduced by the mid-1970's.

In 1976, the Andhra Pradesh Forest Department became part of the Indian Crocodile Conservation Project. During the winters of 1976-77 a detailed survey was carried out of crocodile populations and their habitat in the two Godavari and Krishna river systems and other many reservoirs. The survey revealed the total population estimation to be less than 30 adult mugger crocodiles with only six breeding females. This was a sorry state, considering the state had many suitable habitats for mugger crocodiles, and the mangrove areas in deltaic region of the state are still good habitats for saltwater crocodile.

In 1977, a crocodile breeding and rearing centre was set up at Nehru Zoological Park, and subsequently satellite rearing centres set up at Vishakapatnam Zoo,

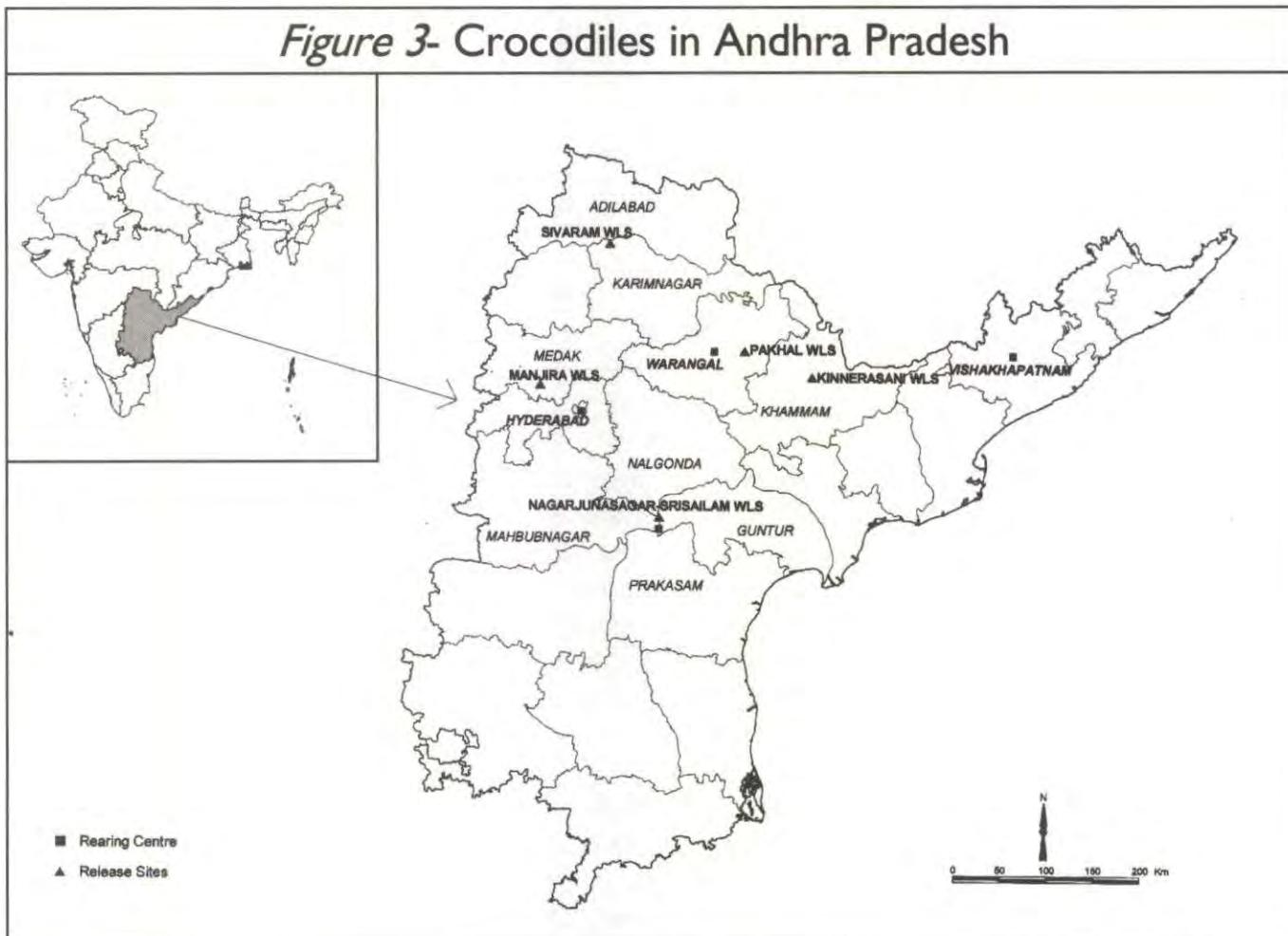
Nagarjunasagar, Warangal, Horsely hills and Manjira Wildlife Sanctuary.

Since then over 1500 mugger crocodiles have been hatched and reared. For some time, the rearing centre at Hyderabad also catered to rearing gharial hatchlings obtained from Nepal and saltwater crocodiles obtained from Andaman & Nicobar Islands. However, the centre has now confined itself to breeding and rearing mugger crocodiles.

Currently, the state project has delinked its wild crocodile egg collection programme, and is involved in rearing crocodiles that breed in captivity at the Hyderabad, Vishakhapatnam, Nagarjunasagar and Warangal facilities. Together in all these facilities, the state holds more than 300 crocodilians belonging to the three species.

Crocodile reintroduction

Since the start of the Crocodile Conservation Project in Andhra Pradesh, over 320 mugger (Table I) and saltwater crocodiles have been released back into the wild in Nagarjuna Sagar – Srisailam Tiger Reserve, Manjira Wildlife Sanctuary, Kinnerasani Wildlife

Figure 3- Crocodiles in Andhra Pradesh

Sanctuary, Siwaram Wildlife Sanctuary, Pakhal Wildlife Sanctuary and Coringa Wildlife Sanctuary. Mugger reintroductions total about 320 (Table 1).

1) Nagarjuna Sagar – Srisailam Sanctuary

As recommended by HR Bustard, Technical Advisor, FAO/UNDP, the Ethipothala Waterfalls (Chandravanka river, tributary of the Krishna river) area was selected and the first ever release of captive-reared mugger (1 male and 3 females) in Asia took place here on 8 February 1977. Subsequent releases (two individuals each) took place on 23 December 1978 and 16 September 1980 respectively. To give adequate

protection to this area, the Nagarjuna Sagar – Srisailam sanctuary was declared and notified in 1978. The sanctuary, now a Tiger Reserve. In April 1981, 128 mugger (2 males and 126 females) were released in Krishna river within the Tiger Reserve and further releases were made in March 1996 in Nagarjuna Sagar (3 male and 2 females). In May 1997, 28 males and 32 females and in September 1998, 17 males and 23 females were released in the Srisailam reservoir. Following the release, the first breeding of the mugger crocodiles in the wild was reported in 1981 at the Ethipothala Waterfalls (Chaudhury and Bustard, 1982).

Table 1
Showing the releases of mugger in Andhra Pradesh

Date of release	Total	Male	Female	Location
Feb. 1977	4	1	3	Ethiopothala Falls, Nagarjunsagar - Srisailam Sanctuary
Dec. 1978	2	-	2	-do-
Sept 1980.	2	2	-	-do-
April 1980	33	11	22	Kinnerasani WLS
Nov. 1980	15	5	10	Pakhal WLS
April 1981	128	2	126	Krishna river, Nagarjunsagar- Srisailam Sanctuary
Jan. 1985	15			Siwaram WLS
Jan. 1985	10			Manjira WLS
May 1989	6	2	4	Manjira WLS
Mar. 1996	5	3	2	Nagarjuna Sagar Krishna River
May 1997	60	28	32	Krishna River Srisailam
Sept. 1998	40	17	23	Srisailam
Total	320			

II) Manjira Wildlife Sanctuary

The wild population of mugger in Manjira WLS was estimated to consists of 7 adults and 5 sub-adults in 1978 (BC Choudhury, unpublished data) where 10 juveniles were introduced in January 1985 and six more released in May 1989. There are reports of this released population breeding in wild since 1987 (Vijay Kumar, 1993).

III) Kinnerasani Wildlife Sanctuary

During the 1997 survey the reservoir on Kinnerasani river within Kinnerasani Reserve Forest in Khammam District was found suitable for crocodile release. It was declared a sanctuary in 1978 and in November 1980 a total of five males and 10 females were released in the reservoir. These mugger are also reported to be breeding in the wild since 1985 (BC Choudhury, 1995).

Status of Saltwater Crocodiles in the Andaman Archipelago

Harry V Andrews

THE ANDAMAN AND NICOBAR archipelago, consisting of over 550 islands, islets and rocky outcrops, with land area of 8,213sq. km and a coastline of 1,962km, lies between 6° 45'N and 13° 41'N and 92° 12'E and 93° 57'E . The saltwater crocodile (*Crocodylus porosus*, Schneider, 1801) was once common and found throughout the Andaman and Nicobar Islands, occurring in the mangrove habitats, considered to be one of the world's largest mangrove ecosystems.

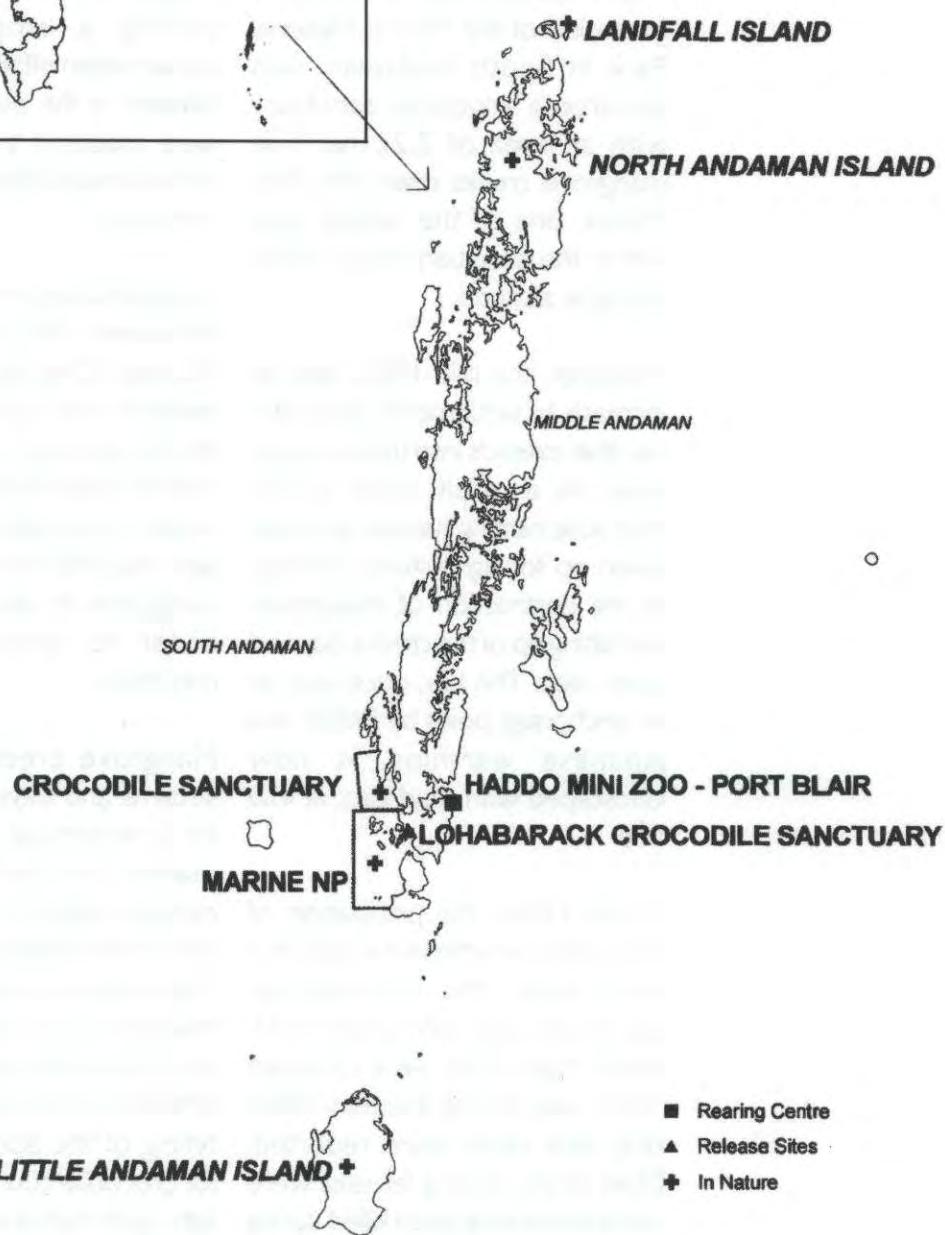
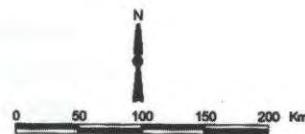
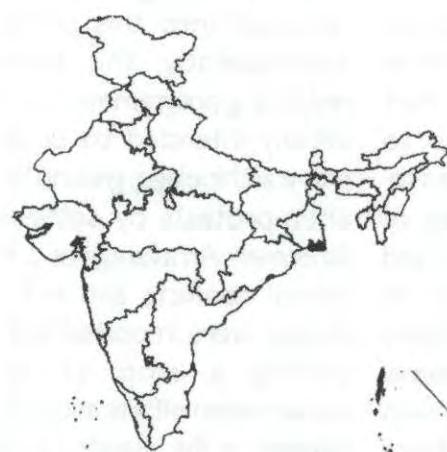
The main habitats of the saltwater crocodile included mangrove creeks, closed bays and freshwater marshes, now scarce and restricted to the island of Little Andaman. The North Reef Island contained an extensive freshwater marsh until 1995, which has turned saline due to sea-water intrusion into the land from the south-western portion of the island. Although an abundance of crocodiles was reported, population estimates for the species could not be substantiated for these two island ecosystems.

Hunting of the species for the skin trade was reported to be rampant during the 1950s and 1960s, until enforcement of the Indian Wildlife

(Protection) Act in 1972. Initial crocodile surveys to estimate the saltwater crocodile population for North Andaman Island began in 1975 (Whitaker & Whitaker, 1978). Subsequently, Choudhury & Bustard (1979) conducted a comprehensive nest survey in North Andaman Island, which provided a more realistic estimate of the population (Choudhury, 1980). The authors reported large scale hunting for the commercial skin trade, prior to 1972, as a major cause for the initial decline in crocodile numbers, in addition to the rapid encroachment of nesting habitats for agricultural practices, killing of nesting females and large scale egg collection by settlers. Surveys conducted in 1993 and 1994 indicated a further decline due to the rapid increase and influx of immigrants and encroachment of flat wetland areas comprising ideal crocodile nesting habitat, intensive mechanized boat traffic and fishing in the creeks, which was taking its toll on the last remaining population (Andrews, 1994 & 1997).

A detailed report on the population dynamics, ecology and movement patterns of *C. porosus* in the Andaman Islands is under preparation.

Figure 4 - Crocodiles in the Andaman Islands



Conservation efforts

In 1976, the Andaman and Nicobar Islands Forest Department initiated a captive rearing and breeding programme at the Haddo Mini Zoo in Port Blair. The objective was to establish a 'rear and release' programme for restocking of crocodiles in wild habitats, and farming of the surplus stock. In 1981, Lohabarrack, a northern extension of the Marine National Park in South Andaman, was declared a crocodile sanctuary with an area of 2,221 ha. Five mangrove creeks drain into Port Mouat, one of the largest bays within the sanctuary area, where fishing is allowed.

However, the mid-1980s saw an increase in settlements along the bay that extends into the sanctuary area. As a result, most of the crocodile nesting habitat has been taken up for agriculture, resulting in the destruction of mangroves and silting up of the creeks, bay and coral reefs. The bay, once used as an anchorage point by British and Japanese warships, is now landscaped with mud flats, at low tide.

In the 1970s, the population of saltwater crocodile in the area that now form the Lohabarrack sanctuary was estimated at 15 adults. Eight nests were recorded in the area, and by the mid-1980s only two nests were reported. Most of the nesting females were reported to have been killed during the nesting season and eggs utilized by settlers. Several juvenile crocodiles trapped in fishing nets

were also killed by fishermen (Khan, pers.com.). In 1986 and 1987, 18 yearling crocodiles were released into this sanctuary. Subsequently, the crocodile restocking programme, which was initially intended to cover the entire archipelago, ground to a halt after protests by settlers and fishermen. An average of 3-4 man-animal conflicts and 6-7 cattle attacks were reported per year, putting a stop to further conservation efforts and crocodile releases in the islands. No efforts were made to translocate these animals, most often killed by baiting methods.

Crocodile Survey in the 90's

Between 1993 and 1999, the Madras Crocodile Bank field research unit conducted two to three surveys every season. Further, some freshwater marshes where crocodiles are difficult to spot required four to five surveys during the dry and wet season in order to assess the marsh condition.

Mangrove creeks, freshwater streams and bays were surveyed on a motorboat and freshwater marshes on foot to assess the current status of these habitats and for the presence of old nests. Day counts were carried out in the mangroves and freshwater creeks during low tide and repeated at different times depending on the timing of the tide. Methods used for crocodile counts included spot lighting at night for eye-shines with a 6V flashlight. Indirect evidence such as tracks, old nests, interviews with local fishermen,

farmers, settlers and the Forest Department were also recorded. Day and night surveys averaged at the rate of 14-16hrs per day, depending on the extent of the creek system. Each habitat was surveyed over different seasons.

Crocodiles have also been often sighted in the open sea, swimming between islands into mangrove creeks and freshwater streams. Tracks and spores have been observed on beaches in several islands covered during the survey.

Results

The population of *C. porosus* in North Andaman Island in mid-1970s was estimated at 15 breeding females and 100-200 individuals (Whitaker & Whitaker, 1978). However, realistic population estimates for this large island was known only by late 1978 (Choudhury, 1980; Choudhury & Bustard 1979). The authors reported 39 animal sightings and 30 nests, estimating the breeding population at 50 females.

Intensive surveys conducted in 1993 and 1994, recorded the adult population to be 95 (Andrews & Whitaker, 1994), excluding Landfall Island where the population was later estimated to be around 38 adults. Later, surveys conducted in North Andaman Island during the nesting season in 1994, showed a drastic decline in the population, mainly due to the intrusion of Thai poachers in May and June, who were reported to be involved in the trapping of adult animals for shipment to farms in Thailand.

North Andaman Island, North Reef Island and Interview Island were extensively surveyed, covering a total of 198 creek systems and 16 bays. A total of 31 adult crocodiles were encountered and 10 nests located, which were found raided, possibly by the North Andaman settlers.

The areas surveyed in Middle Andaman Island comprise the north-eastern, south-eastern and south-western habitats. (The western side falls within the Jarawa Tribal Reserve.)

Surveys conducted in late 1994 and subsequently in 1997 and 1998, estimated the total crocodile population for Middle Andaman Island at 17 adults, 9 sub-adults and 15 juveniles. The entire north-eastern, southern and south-western portion up to Port Mouat in South Andaman Island, was surveyed during 1996-1998. *C. porosus* habitats in Rutland, Tarmugli and Hobday islands were assessed. A total of 19 adults and 35 sub-adults were encountered (Andrews, 1997). Several islands in the Ritchie's archipelago were also assessed. Sub-adult animals were observed migrating from Middle and South Andaman into two creeks south of Havelock Island, and two other creeks located north and south of Outram Island. The habitats were assessed to be less extensive and inadequate for supporting a viable population. The 1.6sq. km flat land in South Sentinel Island, surveyed in 1997 and 1998, was found to be devoid of suitable crocodile habitat.

Crocodile attacks on humans

by Ajai Saxena

Among the major threats the saltwater crocodiles face in the Andaman islands are poaching for commercial gains, both by local settlers as well as foreign poachers, and a negative attitude of the local people towards their conservation, mainly because of crocodile attacks on human beings and cattle, and the resultant retaliatory killings.

Between 1986 and 1993, ten cases of crocodile attacks on human beings were reported - all from the Andaman group of islands. Locationwise, four cases were reported from North Andamans (Kalighat I, Kishorinagar 2, Paschimsagar I), three from South Andamans (Tirur Creek I, Shoal Bay Creek I), and three from Middle Andamans (Kadamtala Creek I, CFO Nallah I and Rangat Nallah I). In three of these cases, three persons lost their lives, while in the remaining seven cases, eight persons were injured.

Habitat destruction and sharing of the same habitat by humans and crocodiles are the major reasons for such man-animal conflict. Forest Department stopped the cutting of mangrove for any purpose in the late eighties, which has resulted in considerable improvement in mangrove forest cover of these islands. But increasing human activities such as fishing in the mangrove areas and crossing the creeks without adequate protection result in such crocodile attacks on humans.

Considering that these islands still provide the best home for saltwater crocodiles in India, there is an urgent need to mitigate the man-animal conflict. This can be done through educating the people, adopting safer fishing and navigational practices as well as providing viable economic alternatives to the local settlers. A better overall protection to the mangrove habitat and crocodiles and reviving captive breeding and restocking programme for saltwater crocodiles, will assure a safer home for this endangered species on a long-term basis.

Little Andaman Island comprises one of the most extensive mangrove creek systems as well as freshwater creeks and streams, including extensive freshwater and saline marshes. One of the freshwater marshes situated on the western side, is a 2.5km long stretch with 1m tall floating vegetation. This is the only island in the Andamans consisting of extensive freshwater creek systems. The entire creek system, streams and marshes on this island were surveyed over a period of four years, during different seasons (Andrews, 1997). The crocodile population on this large island, with extensive habitats was estimated to be 27 adults, 11 sub-adults and 26 animals in the 1m size-class.

Little Andaman Island was

estimated to contain one of the most stable and largest *C. porosus* populations up to early 1992. By mid-1992 and late 1993, Thai poachers were systematically involved in the poaching of live animals of various size classes. Holding enclosures and pens constructed with mangrove poles were set up in the marshes for the purpose. Remnants of these can still be seen in several major mangrove creeks. The last two years have seen an evident decline in the *C. porosus* population in Little Andaman Island, by organised poaching of crocodiles by local poachers from settlements that have mushroomed on the eastern side. In addition, there is a flourishing trade in crocodile skins, fat and internal organs on this island.

Problems and recommendations

The main problems faced in North, Middle and South Andaman Islands is the loss of flat lands adjacent to freshwater sources, comprising prime crocodile nesting habitat, to settlements and agriculture, resulting in the silting up of freshwater streams.

These three island ecosystems are currently assessed to be unsuitable for further conservation efforts. In comparison, most of the habitat in the Little Andaman Island is still pristine, and so, is in urgent need of protection. Restocking the crocodile habitats on this island would ensure a quick recovery of crocodile populations that have been decimated over the years. Crocodiles for releasing could be obtained from the local zoo. There is also an urgent need for the Forest Department to establish a ground staff for protection, law enforcement and monitoring of the last stronghold of the saltwater crocodile on this island.

Other problems include: (a) killing of nesting females at nest sites; (b) poaching for skin, fat and collection of eggs by local settlers; (c) intensive fishing and boat traffic in all the mangrove creeks; and (d) remoteness and inaccessibility of these areas, lack of staff, funding, adequate boats and equipment, which make management and monitoring activities difficult for the Forest Department .

References

ANDREWS, HV (1997) - Population dynamics and ecology of the saltwater crocodile (*Crocodylus porosus* Schneider) in

the Andaman and Nicobar Islands. *Interim report, Phase III*. Submitted to the Andaman and Nicobar Forest Department and the Centre for Herpetology (AN/C-3-97). 6 pg.

ANDREWS, HV and R WHITAKER. 1994. Population dynamics and ecology of the saltwater crocodile (*Crocodylus porosus*) (Schneider) in the Andaman and Nicobar Islands. *Interim survey report, Phase II*. Submitted to the Andaman and Nicobar Forest Department and the Centre for Herpetology (AN/C-2-94). 18 pg.

ANDREWS, HV and R WHITAKER (1994) - Status of the saltwater crocodile (*Crocodylus porosus*, Schneider, 1801) in North Andaman Island. *Hamadryad* 19: 79-92.

CHOUDHURY BC and HR BUSTARD (1979) - Predation on natural nests of the saltwater crocodile (*Crocodylus porosus* Schneider) on North Andaman island with notes on the crocodile population. *J. Bombay nat. Hist. Soc.* 75: 43-49.

CHOUDHURY BC (1980) - The status, conservation and future of the saltwater crocodile (*Crocodylus porosus*, Schneider) in North Andaman Island, Union Territory of Andaman & Nicobar Islands. *Indian Crocodiles- Conservation and Research*. Occl. Publ.. No. 1. pp 1-7.

WHITAKER, R. and Z WHITAKER. 1978. A preliminary survey of the saltwater crocodile (*Crocodylus porosus*) in the Andaman Islands. *J. Bombay nat. Hist. Soc.* 76: 311-323.

Status and Distribution of the Mugger Crocodile in Tamil Nadu

Harry V Andrews

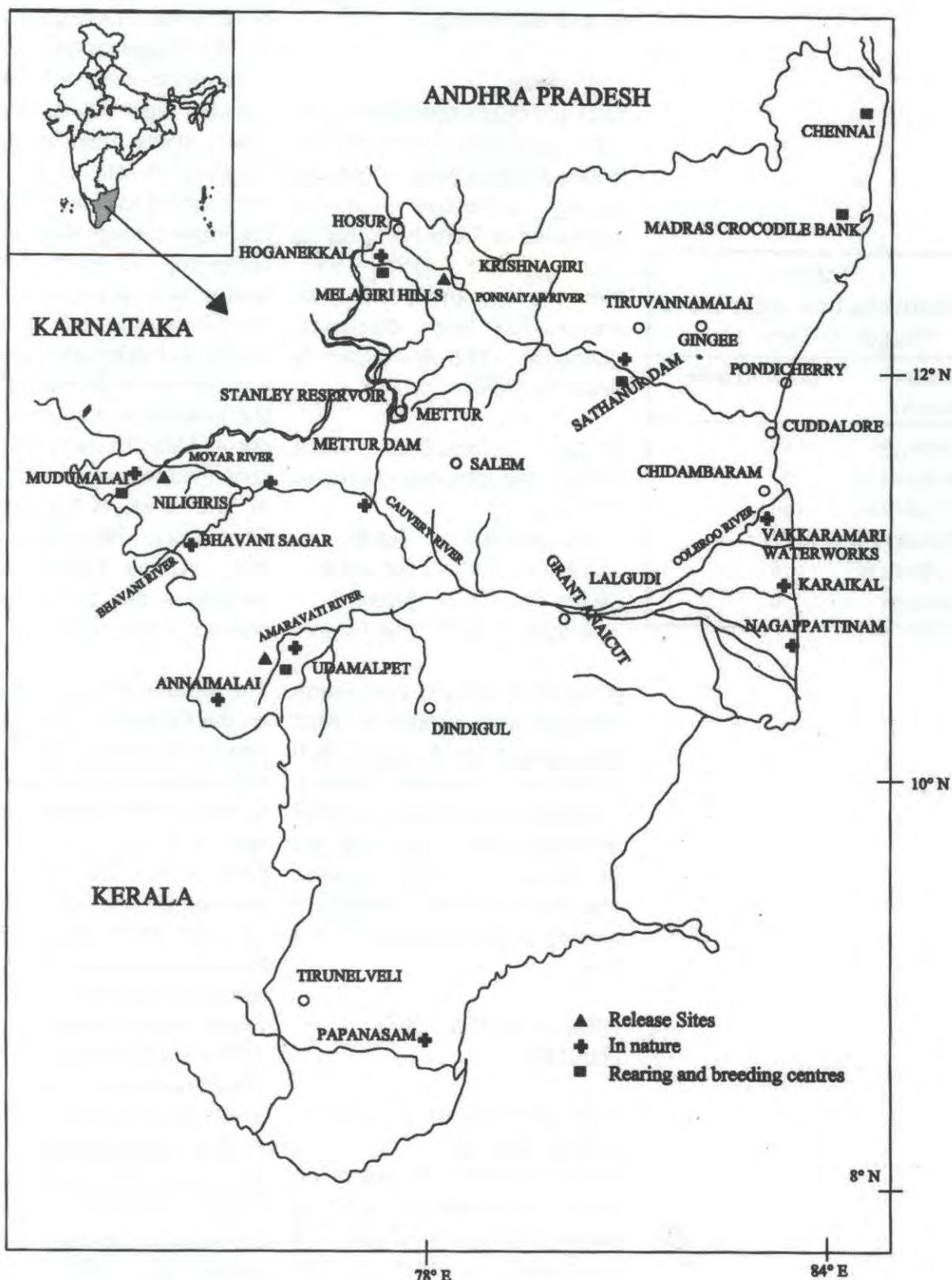
OF THE THREE SPECIES OF crocodiles found in India, the most common and widespread is the broad-snouted mugger crocodile (*Crocodylus palustris*), also known as marsh crocodile, which inhabits all kinds of freshwater habitats such as rivers, lakes, reservoirs, hill-streams, village ponds and manmade tanks. By the late 1960s, their populations were exterminated to extremely low numbers, mainly due to uncontrolled hunting for skin trade. Habitat degradation through damming and channelling of river systems for irrigation, have caused severe fragmentation of habitats and populations throughout the species' distribution range in Tamil Nadu. Preliminary surveys conducted in 1974 and 1976 confirmed the presence of isolated populations in low densities in most of the existing habitats, considered inadequate for supporting a viable population (Whitaker, 1974 & 1976). The population in 1974 was estimated to be 200, declining to 100 in 1979, averaging 75 adult females and 25 adult males (Whitaker, 1979).

Conservation
Conservation efforts for the

revival of the species in the state were initiated in 1976 under the Crocodile Conservation Project. Under this, the state forest department set up four rearing centres. Eggs collected from the wild located within the vicinity of these centres, were successfully incubated and hatchlings reared and released in wild habitats upon attaining 1.5-2m length size. Simultaneously, the Madras Crocodile Bank Trust was set up as a major captive breeding, research and education centre for conservation of all the three Indian crocodilian species.

Reintroduction of mugger crocodiles in the different localities in the state was carried out till the mid-1980s. In 1985, habitat surveys for reintroduction of the species in the Annamalai Wildlife Sanctuary were carried out, and in 1986, 150 *C. palustris* were released at ten different sites within this protected area (Choudhury, 1985 & 1986). By 1986, a total of 372 animals had been reintroduced in six different locations in Tamil Nadu (Choudhury & Chowdhury, 1986) (Table 1). All crocodile reintroductions in the state were carried out in protected areas.

Figure 5 - Crocodiles in Tamil Nadu



However, after this, the programme ground to a halt due to lack of funds for further follow up and monitoring.

Methodology

Data and results presented in this paper are gleaned from literature, studies and field work carried out during extensive surveys conducted in Tamil Nadu during the period 1991-1993. Methodology and animal size classes has been discussed (Satheesh, 1992; Arumugam & Andrews, 1993).

Mugger crocodiles were categorized into size-classes as follows:

1.5m and over	-	Adults
1-1.5m	-	Sub-adults
50cm-1m	-	Juveniles
less than 50 cm	-	Hatchlings

Thiruvannamalai District and drains into the Bay of Bengal north of Cuddalore, on the east coast of Tamil Nadu. During the surveys in 1992, mugger crocodiles sighted 3 km north-west of Krishnagiri included eight adults, two sub-adults, three juveniles and 16 hatchlings. A total of 25 mugger were sighted further south-east of Krishnagiri through Kaveripatnam, comprising 10 adults, four sub-adults, two juveniles and nine hatchlings. Indirect evidence (tracks and slidemarks) estimates included five additional animals in the juvenile and sub-adult size classes. With the exception of the confirmed release of 130 animals in the area (Choudhury & Chowdhury, 1986), the results of the survey could not be compared, due to the lack of previous survey data.

In most instances, population estimates were assessed by direct evidences, and in a few cases from confirmed, reliable reports. Hatchlings have been excluded in the population counts, and the presence of nests located estimated to be the number of nesting females present in the area.

PRESENT STATUS - WILD HABITATS

Krishnagiri, Ponnaiyar River and Sathanur Reservoir

The river system flowing down from Hosur, near the Karnataka border, through Krishnagiri and Kaveripatnam, forming the Ponnaiyar River, courses through the Sathanur Reservoir in

The Sathanur Reservoir, is located on the Ponnaiyar River (Figure 2). Reports by local people conclude that mugger crocodiles were once common, inhabiting the reservoir area and the river, but the population had significantly depleted by the 1960s. In 1976, five nests were collected for the Forest Department's rear and release programme (Whitaker, 1976). Later, Whitaker (1978 & 1979) and Whitaker & Daniel (1980) reported 12 adults, six of which were breeding size females. A survey during the nesting season determined the population to be 30-35, including 13-15 animals in the breeding size-class. During the period 1977-1981, 1541 eggs were collected by the Forest Department for their rear and

Table 1
Reintroduction locations of Mugger in Tamil Nadu

Location	No. of crocodiles released
Krishnagiri	142
Hoganekkal	47
Anaimalai	150
Mundanthurai	21
Mudumalai	6
Sathanur	6

release programme (Vijaya, 1981).

Surveys conducted in 1993 determined the presence of 50 adults, comprising 20-23 breeding females, 12 sub-adults and 20 in the juvenile size-class (Arumugam & Andrews, 1993). Considering that no re-introduction programme was conducted in the reservoir, a comparative population estimate for the period 1977-1981 indicates a stable and upward trend in the population, thus demonstrating the view that a carefully managed egg harvesting programme is possible, with no significant impact on the population.

Hogenekkal Cauvery River System
The Hogenekkal Falls, within the Cauvery river system, is situated close to the Karnataka border on the western side of Tamil Nadu. The Cauvery flows from below the Falls, south around the Melagiri hills into the Stanley Reservoir and Mettur Dam, continuing eastward to Tamil Nadu, branching out into several tributaries before draining into the Bay of Bengal (Figure 2). During the mid-1970s, the area was estimated to have a small population of less than 10 mugger (Whitaker, 1974). During the early and mid-1980s, 47 captive reared mugger were released in the area (Choudhury & Chowdhury, 1986). However, surveys conducted during 1992 and 1993 confirmed the presence of only 15 adult mugger in this river system. The sightings of hatchling and juvenile animals indicated the presence of breeding females. Habitat assessment carried out during

these surveys determined the entire stretch to be inadequate to support a larger population and, it was concluded, most of the animals may have moved further downstream along the Cauvery, suggesting further assessment (Satheesh, 1992).

The Mettur Dam has a water spread area of 96sq. km., with most of the water being channeled out to Thanjavur for irrigation. A 1974 status report estimated the mugger population in this reservoir to be less than 10 animals (Whitaker, 1974). A survey in 1992 reported only a single sighting, and no indirect evidences of other crocodiles. Local Forest Department personnel and fishermen also report the frequent sighting of one lone *C. palustris*. The entire stretch of the Cauvery river from the Mettur Dam to Srirangam supports a large human population, where settlements and villages extend right up to the riverbanks. However, over the years, isolated sightings of mugger have been reported in the area, suggesting the possible migration of crocodiles downstream towards the Coleroon river area. Four adult mugger were sighted in 1992 at Kalannai, Grand Anaicut, a 200 A. Karikala Chola Dam, situated at the junction of the Cauvery and Coleroon rivers. Local people reported the presence of two to three crocodile near Lalgudi.

Vakkaramari Water Works

The Vakkaramari pump station consists of two major water tanks, located 5km south of

Chidambaram (Figure 3) in the delta between the Cauvery and Coleroon river systems. In the 1970s, the marsh crocodile population was estimated to be 15-20. The long distance migration of *C. palustris* from these two tanks was also reported by Whitaker (1974). In a survey conducted in 1976, 15 animals in the adult and sub-adult size-classes were reported, including the collection of three nests in the area (Whitaker & Whitaker, 1976). Surveys in 1991 and 1992 reported six mugger in the area: two adults and two juveniles by direct sightings, and reported sightings of two adults by local people, one of which was sighted in a village pond at Sivayam, 1km away from the tank (Satheesh, 1992).

The Moyar River System and Bhavani Sagar Dam

The Moyar river courses down the Nilgiri peaks through the Mudumalai plateau and Wildlife Sanctuary, up to the Moyar Gorge between Tamil Nadu and Karnataka, before finally draining into the Bhavani Sagar Dam, from where it joins with the Cauvery river (Figure 2). This river system was comprehensively and systematically surveyed over various seasons between 1991 and 1993 (Satheesh, 1992; Andrews & Arumugam, 1992). The Moyar stretch between Thorapalli and Teppakadu was surveyed by the author in 1993. Six adults over 2.5m in size, two juveniles and 19 hatchlings were sighted. A group of 11 hatchlings were sighted near Kargudi, and

another group of eight sighted 1km west of Teppakadu, indicating the presence of at least two breeding females in this stretch. Several follow-up surveys revealed the presence of six animals, including hatchlings in varying numbers. However, the habitat is prone to human-induced disturbances, making this small, pristine 3.8km stretch inadequate to support a larger population. The entire stretch of the river in the Moyar valley from the Power House right up to the Bhavani Sagar Dam, including the Kaderhalla and the Segur rivers that flow down into the Moyar, was surveyed in 1992 and 1993.

The Kaderhalla is not a perennial river but contains two pools inhabited by two females, which nest annually in the area. Both females were identified during the survey, including sightings of hatchlings and three juveniles. However, the rest of this river system is heavily silted, practically drying out in the summer months (Andrews & Arumugam, 1992). During the surveys in 1976, three nests were located and the total population was estimated to comprise six breeding females (Whitaker & Whitaker, 1976 & 1977). The perennial Segur river that drains into the Moyar river, is inhabited by two to three breeding females. Hatchlings and two juveniles were also sighted.

Intensive surveys from the Kolkombe Power House down to the Bhavani Sagar Dam revealed a total of 94 *C. palustris* along this stretch, which included 54 adults.

Final estimates through direct sightings and excluding hatchling counts, puts the total population of adults, sub-adults and juveniles at 178 in the Moyar system (Table 2). This suggests that the Moyar valley is definitely one of the last pristine *C. palustris* habitats in Tamil Nadu, with a viable and stable population of crocodiles. Other survey observations and habitat assessments establish that this area encompasses a fairly rich ecosystem of faunal diversity (Andrews & Arumugam, 1992).

The Bhavani river which drains into the Bhavani Dam, consists of five pools, 20 km west of Mettupalayam, where there are at least three breeding females. Hatchlings and yearlings have been sighted in this river. Hatchlings and juveniles are also often found in the fish breeding and rearing tanks of the Fisheries Department. During the surveys conducted in the Bhavani Sagar Dam in 1991 and 1992, two-three adults, seven juveniles and three sub-adult animals were sighted, suggesting migration of juveniles and sub-adults from the Moyar river into the dam. The area was surveyed during two nesting seasons. A single nest was found in 1992, which contained a two-day old clutch of 38 infertile eggs. The intensive fishing activities in the dam and agriculture in the surrounding area makes the habitat unsuitable for crocodiles.

Amaravati Reservoir and Annamalai Wildlife Sanctuary

The Amaravati reservoir, with an area 9.31 sq. km, is situated in the

Indira Gandhi Wildlife Sanctuary. Several large streams, namely, the Chinnar, Thenar and Pambar drain into this dam, and thereafter continue as the Amaravati river, finally meeting with the Cauvery.

The Amaravati reservoir was reported to contain the largest *C. palustris* population in Tamil Nadu, supporting 25 adults, including 12 breeding females (Whitaker & Daniel, 1980; Whitaker, 1979). In 1974, 22 animals were recorded during a night survey, 14 adults and 11 nests during a day-time survey (Whitaker & Whitaker, 1977). In 1983, 15 nests were reported, and the population was estimated to be 50, including all size-classes (Davidar, 1983). Subsequently, a total of 38 adults were reported and several more adult animals in the Chinnar river (Satheesh, 1992) (Table 2). During a nesting ecology study in 1994, only five nests were found. The low nesting intensity around the reservoir was attributed to the change in the habitat over the years. Subsequently, eight nests were located along the stream habitat (Vasudevan, 1997). The total population for the reservoir, including the rivers that drain into it, is currently estimated to be 60 adults and 37 sub-adults.

Upper Aliyar Reservoir

This small reservoir is located in the Annamalai hill range of the Western Ghats in the Annamalai Wildlife Sanctuary. Although historically it is outside the distribution range of the species, 20 captive-bred animals were released in the area in 1985

Table 2
***Crocodylus palustris* population structure in different locations in Tamil Nadu**

Location	Adults	Sub-adults	Juveniles
Krishnagiri- Ponnaiyar River	18	6	10
Sathanur Dam	50	12	20
Hoganekkal	15	4	5
Mettur Dam			
Cauvery River	1	-	-
Kalannai, Kilikudu-	14	2	-
Grand Anaicut, Coleroon, Lalgudi, Vakkaramari			
Moyer River system,	65	43	86
Bhavani Sagar Dam, Bhavani River			
Amaravati Sagar Dam area	48	17	18
Upper Aliyar Reservoir	16	-	-
Mundanthurai			
Tambaraparani River	15	-	-
Total	242	84	139

(Choudhury, 1986). By 1992, only 16 individuals still inhabited the area, mostly in the 1.5-2.5m size-class. Surveys and assessments determined the lack of suitable nesting habitat (Satheesh, 1992).

Mundanthurai-Kalakkad Wildlife Sanctuary

The Tambaraparani river was dammed at Karayar in Mundanthurai, in the Kalakkad Wildlife Sanctuary. Further downstream, the river is dammed at Papanasam. Four animals were sighted during surveys in 1992 (Satheesh, 1992) and another three animals in 1993 (Ali, pers. comm.). In 1986, 21 captive reared animals in the 2-2.5m size-class were released in Mundanthurai, which are likely to have dispersed along the river, suggesting further

assessment (Satheesh, 1992). The present estimated population in this system is 15 adults.

STATUS - CAPTIVITY

Sathanur Crocodile Centre - The Sathanur Crocodile Centre, situated 40km south-west of the pilgrim town of Thiruvananamalai was established by the Tamil Nadu Forest Department in 1977 for purposes of crocodile reintroduction. A total of 185 eggs were collected from the wild, hatched and the animals reared for the Centre's release programme. At present, the Centre has a stock of 444 mugger crocodiles, mostly comprising animals of the breeding size-class, housed in 30 enclosures. The facility is well maintained by six staff appointed

by the Forest Department. A breeding programme is underway. However, no records are being maintained and animals of different size-classes are housed together. Size-sorting the animals in different groups is urgently required for facilitating better growth rate. Feed comprises beef and bones, supplied every alternate day (Kailas, 1999).

Tourists who visit the Dam also visit the Crocodile Centre and are charged a nominal fee of Re 0.50 averaging a monthly income of Rs.25,000/- . The cost of feed amounts to Rs. 22,000/- per month. It is recommended that an increase in entrance fee to Rs.2/- per person, would help recover the cost of maintaining the Centre and for further developing the tourism facilities.

Amaravati Sagar Crocodile Farm
Established in 1975, this is the largest government rearing station. Eggs collected from the perimeter of the Dam are hatched and reared at the Farm. Several of these animals have been reintroduced into the wild (Choudury, 1986). Females hatched in 1975 and 1976 began breeding in 1983 (Davidar, 1983). Currently, 430 animals are maintained in captivity, most in the adult size-class. Three Forest Department personnel manage and maintain the Centre, under the overall charge of a Range Officer (Kailas, 1999).

Masinagudi Rearing Station

The Masinagudi Crocodile Rearing Station is situated on the edge of

the Mudumalai Wildlife Sanctuary. The rearing station has a total of 30 adult animals, maintained by a staff of three belonging to the Forest Department staff. The entire group are from eggs and hatchlings collected along the Moyar River system.

Hoganekkal Rearing Centre

The Hoganekkal Rearing Centre was started in 1975. Since then, 130 animals from this station have been released into the Krishnagiri and Ponnaiyar river systems in the late 1970s and early 1980s. A total of 190 mugger crocodiles are being maintained here, comprising mostly adult animals. Currently, the Centre is faced with the problem of overcrowding of animals in enclosures.

Madras Crocodile Bank Trust

The Madras Crocodile Bank Trust, located 50km south of Chennai on the Coramandel Coast was established for the conservation and study of India's three crocodilians: the mugger crocodile (*C. palustris*), the saltwater or estuarine crocodile (*C. porosus*) and the gharial (*G. gangeticus*). Since its inception, the Bank has carried out extensive research on crocodilians both in captivity and in wild habitats. Starting with a few adults and about 30 hatchlings, the Bank has been extremely successful in breeding all three species, including seven endangered and exotic crocodilians species maintained in captivity. In addition, the Bank has witnessed the successful breeding of F2 and F3 generation mugger crocodiles in captivity. Over 900

Table 3
Number of *Crocodylus palustris* held in captivity in the different project centres in Tamil Nadu

Name of Centre	No. of Crocodiles	Remarks
Sathanur Crocodile Rearing Centre	444	Mostly adults, reported breeding in 1980s
Amaravati Sagar Crocodile Farm	430	-do-
Hoganekkal Rearing Centre	190	Mostly adults
Masinagudi Crocodile Rearing Station	30	Adults, mostly stunted and in unhealthy condition.
Madras Crocodile Bank Trust	2,802	Mostly adults

animals have been supplied for restocking and breeding programmes of the various State Forest Department in the country and to zoos in India and abroad. The resultant stock pile up from the tremendous breeding success, and the halting of further restocking activities in the country in 1984, forced the Bank to terminate the breeding of *C. palustris* in 1992. Currently, 2802 *C. palustris* of various size classes are maintained here, of which 1173 are adult and sub-adult animals, and the remainder juveniles (Whitaker & Andrews, 1992). A drastic move is on to offload the existing surplus stock to Indian and foreign zoos, so as to reduce the mortality rate of animals due to overcrowding and the high maintenance costs.

Discussion and conclusion

Despite the enormous pressures encountered, particularly from habitat loss and human encroachment, conservation

efforts for the survival of *C. palustris* in Tamil Nadu have been notably successful. Surveys and assessments carried out in 1991 and 1992 indicate that *C. palustris* populations are stable only within protected areas. A drastic decline in mugger populations was observed in areas prone to severe human pressures, mainly due to habitat alteration and fragmentation. Reduction and degradation of crocodile nesting habitat and poaching of eggs, has affected populations. Dispersal and migration of sub-adult and juvenile size-class animals into human habitation where their chances of survival is further reduced, poses another problem. There is an urgent need to implement the management plans drawn up in 1993 and 1997, and of continued monitoring and initiation of a sound environmental education programme for people living in and around crocodile habitats.

Studies conducted during the same period also indicate that the constantly changing manmade or altered habitats are inadequate to sustain larger and viable populations. Some of the major factors that have had an affect on mugger populations include the silting up of dams over the years, decrease in depth and increase in water spread area. The reduction in water levels and drying up of streams and dams during the summer months have taken their toll, causing fish populations to die out and dispersal of mugger crocodiles to unfavourable habitats, in most cases human habitation, where their survival is at risk and re-migration is next to impossible. The increase in water spread area causes further damage and reduces nesting habitat area, as indicated from observations made at sites such as the Amaravati and Bhavani Sagar dams (Davidar, 1983; Satheesh, 1992; Andrews & Arumugam, 1992; Vasudevan, 1998). Findings indicate that the carrying capacity in altered habitats is limited, with little or no chances for a viable recruitment rate and dispersal for juveniles and sub-adults. Other problems affecting altered habitats is the intensive fishing and agricultural activities around these areas, including the frequent use of fertilizers and pesticides by local settlers, aggravated by the ever-increasing human habitation in these areas.

Extensive studies conducted in the Moyar river strongly suggest that it is the last-remaining pristine habitat suitable for the future

conservation and survival of mugger crocodiles in Tamil Nadu. Considering the total mugger population and the extent of its habitat, the pressure is considerably lesser here than in other areas, as it falls within a protected sanctuary zone, thus providing for a well-managed conservation programme, with minimal cost and effort.

State-wide surveys and habitat assessment results confirm the status of *C. palustris* as follows:

- a) Most *C. palustris* populations in the state are fragmented.
- b) Stable populations are restricted only to protected areas.
- c) Populations in protected areas and in dam sites have reached saturation limits.
- d) There is distinct lack of area for further dispersal within protected areas and no viable habitat outside protected areas, in particular for juvenile and sub-adult size-classes.
- e) Small, fragmented, populations consisting of a few individuals existing outside protected areas, cannot provide future viable populations due to the relative destruction and disturbance of their nesting habitat resulting in low survival and recruitment rates.
- f) Results of habitat assessments suggest lack of suitable habitat for further restocking or reintroduction of *C. palustris* in Tamil Nadu.
- g) Altered habitats like dams are not optimum habitat for *C. palustris*.
- h) Stock piles of surplus *C.*

palustris in the five centres have become a tremendous burden on resources and space.

Tamil Nadu was the only state in the country, appointed to review and conduct a pilot study for farming of *C. palustris*. The proposal needs to be revived, reviewed and a feasibility study urgently implemented. A proposal for a one-time cull, should be considered, in order to ease the present problems faced in these captive centres.

References and selective bibliography

ACTION PLAN (1998) - Biodiversity conservation in wetland habitats. Crocodilians. Report of the First Western Asia Regional Conference of the IUCN/SSC Crocodile Specialist Group, 5-7 June, 1997, Jiwaji University, Gwalior, Madhya Pradesh, India. MCBT/CSG, 1998. 19 pg.

ANDREWS, HV (1986) - Preliminary report on mugger breeding at Madras Crocodile Bank Trust for 1986. *Hamadryad* 11(1, 2): 2.

ANDREWS, HV (1986) - Variation in eggs and clutch size of mugger in different size classes. *Hamadryad* 11(3): 13-14.

ANDREWS, HV (1986) - Mugger, caiman and saltwater crocodile breeding at the Madras Crocodile Bank. *Hamadryad* 11(3): 10-12.

ANDREWS, HV (1987) - A note on the mugger breeding and nesting activities at the croc bank. *Hamadryad* 12(2): 17-18.

ANDREWS, HV (1988) - A bumper crop of mugger. *Hamadryad* 13(1): 2-3.

ANDREWS, HV and R ARUMUGAM (1992.) - Conservation and biology of the mugger crocodile: Studies in natural and altered habitats and continued survey. First Interim Report submitted to the Centre for Herpetology/Madras Crocodile Bank Trust. Aug/Dec. 1992. 4 pgs.

R ARUMUGAM and HV ANDREWS (1993) - Status of the mugger crocodile (*C. palustris*) in the Sathnur Reservoir, Tamil Nadu. Report submitted to the Centre for Herpetology/Madras Crocodile Bank. C-1/93, August 1993. 8 pgs.

CHANDI, M (1995) - Wildlife conservation and sustainable development, crocodile farming as a welfare resource. Master's Dissertation. Department of Economics, Madras Christian College, Tambaram, Madras 600039, south India. 71 pg.

CHOUDHURY, BC (1985) - Selection of mugger crocodile re-stocking habitats in Annaimalai Wildlife Sanctuary, Tamil Nadu. Mimeo. August, 1985. 10 pgs.

CHOUDHURY, BC (1986) - Release of mugger crocodiles in Annaimalai Wildlife Sanctuary, Tamil Nadu with notes on individual marking and plan for monitoring programme. Mimeo. June 1986. 6 pg.

CHOUDHURY, BC (1987) - Crocodile conservation. The Indian experience. *Vivekananda Kendra Patrika*. August 1986: 71-78.

CHOUDHURY, BC and S Chowdhury (1986) - Lessons from crocodile reintroduction projects in India. *Indian Forester* 112(1): 881-890.

DAVIDAR, M (1983) - Amaravathi crocodile farm. *Hamadryad* 8(3): 24-25.

KAILAS, R (1999) - Captive centres of *C. palustris* in Tamil Nadu. *Interim Report* submitted to the Centre for Herpetology, Madras Crocodile Bank Trust, March, 1999.

LANG, JW, R WHITAKER and HV ANDREWS (1986) - Male parental care in mugger crocodiles. *National Geographic Research* 2(4): 519-525.

LANG, JW, R WHITAKER and HV ANDREWS (1989) - Sex determination and sex ratios in *Crocodylus palustris*. *American Zoologist* 29: 935-952.

LANG, JW and HV ANDREWS (1994) - Temperature-dependent sex determination in crocodiles. *J. Exp. Zool.* 270: 28-44.

LANG, JW, RK AGGARWAL, KC MAJUMDAR and L SINGH (1993) - Individualization and estimation of relatedness in crocodilians by DNA fingerprinting with BKM-derived probe. *Mol. Gen. Genet.* 238: 49-58.

RAJESH, R (1998) - Structural studies on crocodile haemoglobin. *M. Sc. Dissertation*. Department of Biochemical and Molecular Biology. University of Madras, Guindy Campus, Chennai. 34 pg.

ROSS, JP (ED.) (1998) - Crocodiles: Status survey and conservation. *Action Plan. 2nd Edition*. IUCN/SSC Crocodile Specialist Group. IUCN, Gland, Switzerland and Cambridge, United Kingdom. Viii + 96 pgs.

SATHEESH, S (1992) - A preliminary status survey of the mugger crocodile (*Crocodylus palustris*, Lesson) in Tamil Nadu. Report submitted to the Centre for Herpetology/Madras Crocodile Bank. 32 pg.

SINGH, LAK, SK KAR and BC CHOUDHURY (1984) - Indian crocodilians: A 10 year review of management papers presented at the Working Meeting of the IUCN/SSC Crocodile Specialist Group Caracess, Venezuela, October, 1984.

SINGH, L and SP RAY-CHAUDHURI (1973) - DNA replication pattern in the chromosomes of *Crocodylus palustris* (Lesson). *Nucleus* 16: 33-37.

STACEY, B (1998) - The trouble with high density: Veterinary aspects of the Madras Crocodile Bank Trust. *Proceedings of the 14th Working Meeting of the Crocodile Specialist Group*. Singapore, 13-17 July, 1998. IUCN- The World Conservation Union, Rue Manuverney 28, CH-1196, Gland, Switzerland. Pp 407-410.

VASUDEVAN (1997) - Nesting ecology of the mugger crocodile (*Crocodylus palustris*) in Amaravathi, South India. *Hamadryad* 22(2): 107-110.

VIJAYA, J (1981) - Crocodile nesting at Sathanur. *Hamadryad* 6(2): 3-4.

WHITAKER, R (1974) - Notes on behaviour, ecology and present status of the marsh crocodile (*Crocodylus palustris*) in south India. Report submitted to the Madras Snake Park Trust. 22 pg.

WHITAKER, R (1976) - Status and ecology of the marsh crocodile in south India. Madras Snake Park Publication. Field Report, 1976. 5 pg.

WHITAKER, R (1977) - A note on crocodile sex determination. *J. Bombay nat. Hist. Soc.* 73(3): 531-532.

WHITAKER, R (1978) - The status of the mugger crocodile (*Crocodylus palustris*) in India. *National Association of Sound Wildlife Programmes* 2(2): 1-3.

WHITAKER, R (1979) - Crocodile egg collection in Tamil Nadu. *Indian Forester* 105(2): 5-8.

WHITAKER, R (1979) - Future of crocodiles in Tamil Nadu. *Indian Forester* 105(8): 1-2.

WHITAKER, R (1984) - Captive breeding of crocodiles in India. *Acta Zoologica* 78: 309-318.

WHITAKER, R (1989) - Our next domestic animal. New York Herpetol. Soc. 12:1.

WHITAKER, R and HV ANDREWS (1988) - Notes on crocodilian locomotion. *J. Bombay nat. Hist. Soc.* 85(3): 621-622.

WHITAKER, R and HV ANDREWS (1989) - Chemical immobilization of the mugger crocodile (*Crocodylus palustris*) with Gallamine Triethiodide. *Indian Forester* 115(5): 355-356.

WHITAKER, R and HV ANDREWS (1989) - First record of a skin nematode on an Indian mugger crocodile (*Crocodylus palustris*). *J. Bombay nat. Hist. Soc.* 86(1): 106.

WHITAKER, R and HV ANDREWS (1992) - The Madras Crocodile Bank. *Contributions in Herpetology*. Pp 77-83. P. Strimple & J. L. Strimple (Eds). Greater Cincinnati Herpetological Society, Cincinnati, USA.

WHITAKER, R and HV ANDREWS (1998) - Farm a crocodile and save a tiger. *Seminar* 466: 5.

WHITAKER, R and JC DANIEL (1980) - The status of Indian crocodilians. *J. Bombay nat. Hist. Soc. Supplement* 75: 1238-1245.

WHITAKER, R and Z WHITAKER (1977) - Collection and hatching of marsh crocodile (*C. palustris*) eggs. *J. Bombay nat. Hist. Soc.* 73(2): 403-407.

WHITAKER, R and Z WHITAKER (1977) - Notes on natural history of *Crocodylus palustris*. *J. Bombay nat. Hist. Soc.* 74(2):358-360.

WHITAKER, R and Z WHITAKER (1982) - A taxonomic note on mugger subspecies (*Crocodylus palustris*). *J. Bombay nat. Hist. Soc.* 79(2): 426-427.

WHITAKER, R and Z WHITAKER (1984) - Reproductive biology of the mugger (*C. palustris*). *J. Bombay nat. Hist. Soc.* 81(2): 297-316.

WHITAKER, R, Z WHITAKER and A. VAUGHAN (1981) - Notes on sexing crocodilians. *J. Bombay nat. Hist. Soc.* 77: 341-343.

(1993) - Crocodile conservation and management in India. Report on a CSG workshop held at the Madras Crocodile Bank, India 1-3 March, 1993. 27 pg.

Crocodile Conservation in Kerala

KGM Pillai

KERALA, FLANKED BY THE coast line in the west and the ghat regions in the east, interspread with 41 west flowing and three east flowing rivers with many lakes and lagoons; is located between latitude $8^{\circ} 18'$ and $12^{\circ} 48'$ and longitude $74^{\circ} 52'$ and $77^{\circ} 22'$. The climate is of the monsoon type with a dry season lasting about four months from January to April. The temperature is moderate due to the influence of the sea and the altitude. High productivity of the soil and heavy rainfall have formed luxuriant vegetation in the state which supports the magnificent fauna. However, due to over utilization there is impoverishment of the wildlife and regression of the habitat in Kerala.

The estuarine crocodile (*Crocodylus porosus*) is locally extinct in Kerala, the last being shot in the post independent period near Thaneermukkum in Alleppey district where a remnant mangrove habitat still exists. "Sangham literature" has beautiful picturization of the nesting ecology and behaviour of the estuarine crocodiles of the erstwhile Malabar region. The large waterbodies in the Malabar coast and the reservoir, lakes, lagoons

and the temple ponds of the rest of the Kerala portions once boasted a large number of crocodiles. The local belief still holds that His Holiness Shri Sankaracharya, when a child, was bathing in the Periyar river when a mugger crocodile dragged him into the water; and it released the boy only when his mother agreed to the boy entering sanyasa. Crocodiles, indeed, are intrinsically related to the cultural milliu of the people of Kerala.

However, the decline in the population of the crocodilians has been precipitous in the first half of this century and catastrophic in the post-war period. The vast decline in the population of the crocodiles in Kerala came to the attention of the conservation agencies in the early 70's and joint efforts were made to salvage the crocodile from the threat of extinction.

State crocodile conservation programme

As a corollary to the Indian Crocodile Conservation Project, (Government of India/FAO/UNDP), crocodile conservation centres were also started in Kerala

crocodile conservation in India, and Kerala is no exception. The expertise and experience gained by the personnel remain unutilized for crocodiles rearing and management and the personnel are now attending to work related to general biodiversity conservation. There is an urgent

need to revitalize the crocodile conservation programmes in all the identified centres and earnest efforts are necessary to switch over to at least a few pilot commercial crocodile farms, taking into account the potential of the species for national welfare.

Crocodile Conservation in Maharashtra : Problems and Prospects

MG Gogate

IN MAHARASHTRA, THE RIVER systems of the Godawari and Krishna (both originating in the Sahyadri ranges) and the Tapi (emerging from the Satpura hills along the northern boundary of the state), along with their tributaries, harbored the Indian 'mugger' crocodiles (*Crocodylus palustris*) in reasonably adequate numbers till the mid-1960's. Presence of mugger crocodiles in the rivers of central India including Godawari and Tapi tributaries as well as in forest pools has also been reported by Dunbar Brander. No reports, however, are available regarding the presence of saltwater crocodiles *Crocodylus porosus* in the coastal areas of Maharashtra.

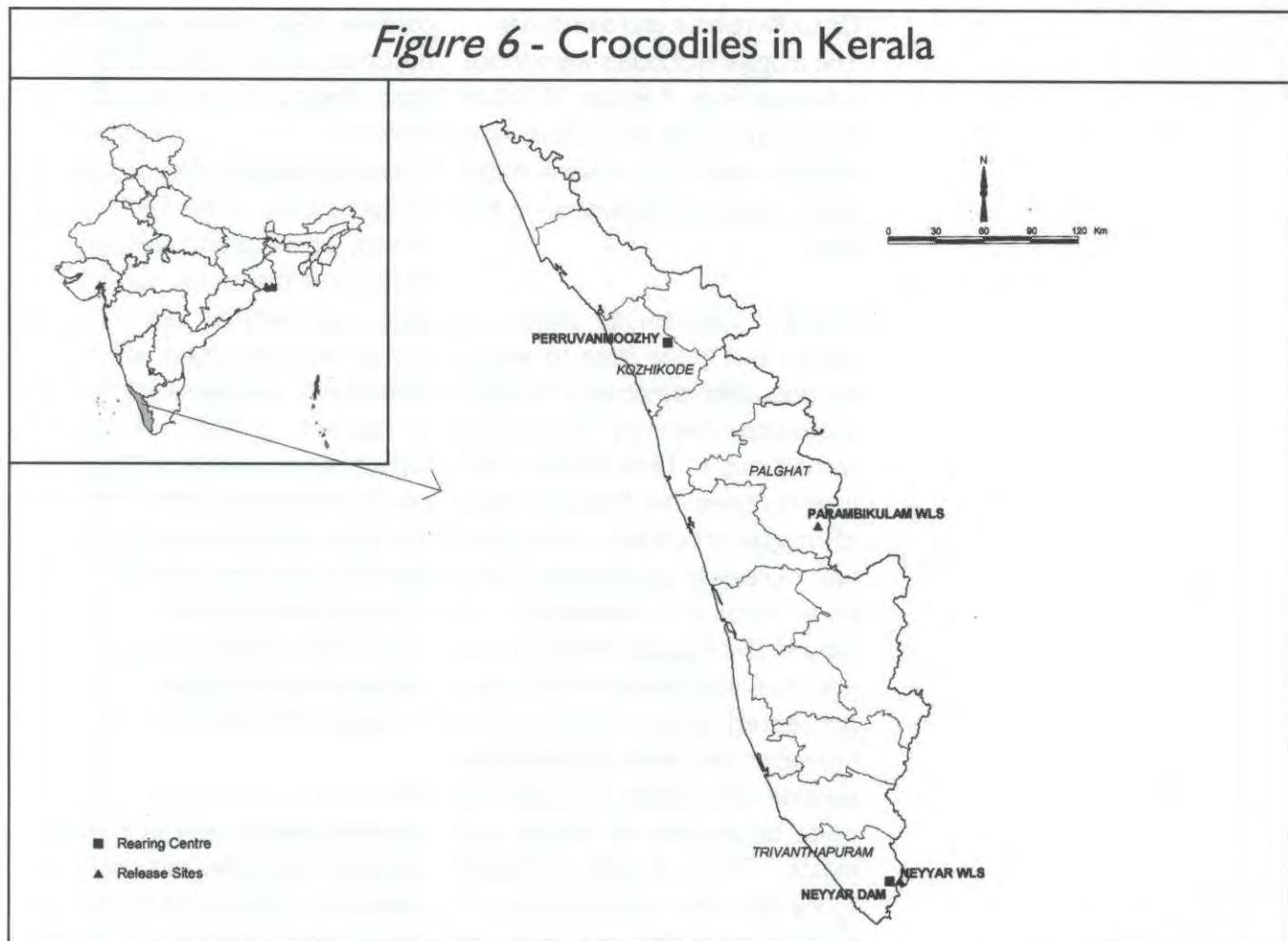
Recent record of crocodiles

The author has observed crocodiles in the coastal areas of Vashiti river near Chiplun in Ratnagiri district as also in ponds in Goregaon vandre in Mumbai prior to 1960. During 1956-57, crocodiles were observed in the Dahisar river, which flows through Krishnagiri Upwan, located, adjacent to the present Sanjay Gandhi National Park, Mumbai. There have been a number of reports on the presence of mugger

in Krishna river near Sangli till 1996. Inquiries with the field staff have confirmed presence of crocodiles in rivers Wainganga, Pranahita, Godawari and Indrawati in Bhandara, Gadchiroli and Chandrapur districts till the late sixties but thereafter there have hardly been any reports, perhaps due to severe depletion of their population as a result of the crocodile-fisheries conflicts. Hunting for skin, but more importantly, habitat destruction have nearly wiped out crocodiles from the major known habitats in Maharashtra.

Inclusion of the mugger crocodile in Schedule I of Wildlife (Protection) Act, 1972 was a little late in protecting this species outside the protected areas. The network of protected areas in Maharashtra did not cover any wetland or marine eco-system till late 1980's. The creation of Jaikwadi, Nandur-Madhmeshwar, Koyana and Bor sanctuaries in 1985-86, which encompass large reservoirs, has also not really helped in conservation of crocodilian fauna because of administrative problems.

Pawi, which is outside Sanjay

Figure 6 - Crocodiles in Kerala

for mugger crocodiles (*Crocodylus palustris*) – one at Neyyar dam (Trivandrum district) and another at Peruvannamoozhy (Calicut district) in 1977. During the period, the status survey revealed that the estuarine crocodiles were locally extinct in Kerala and the mugger were discontinuously distributed in low numbers in the waterbodies, especially of Neyyar reservoir and Parambikulam reservoirs and in Kabani river near Waynad. The population of the mugger crocodile then was less than 60 in the wild in the state. At the time, muggers were then exhibited in the Trivandrum Zoological Park and Trichoor Zoo without any facilities or attempts for captive breeding.

With a batch of 12 yearlings from the Madras Crocodile Bank and three specimens collected from nearby places, the captive rearing programme for mugger crocodiles started in the Neyyar Crocodile Centre. The centre with adequate infrastructural facilities continued to rear the mugger crocodiles. Currently, there is a surplus population of 192 mugger crocodiles of different age, size categories at this centre. There are also five large sized muggers in Peruvannamozhy. Due to paucity of funds, and means for other economical assistance, a low priority is given to the captive rearing and management including captive breeding programmes of mugger in the state.

Crocodile release and monitoring

The mugger crocodiles were thrice released into Neyyar Wildlife Sanctuary and Parambikulam Wildlife sanctuary where there is a viable population in the state.

Periodic crocodilian census is carried out in the state to assess the population dynamics of mugger crocodiles in the state. The census carried out in 1991, 1994, 1997 have revealed that the population of mugger crocodiles in the wild has increased considerably and now there is a population of around 250 muggers in the various age, sex categories in the two protected areas in the state. However, the status of this reptile outside the protected areas is quite bleak and the threat still exists. There is also sufficient scope for the reintroduction of mugger crocodiles into many of the natural habitats still available, after observing the guidelines of release of a super predator.

Man-crocodile conflicts

The crocodile attacks on man and his domestic stock and the injuries inflicted on human beings have raised much hue and cry. There have been references to the subject in the Legislative Assembly of the state. Many features on crocodiles-man conflict had also appeared in the media.

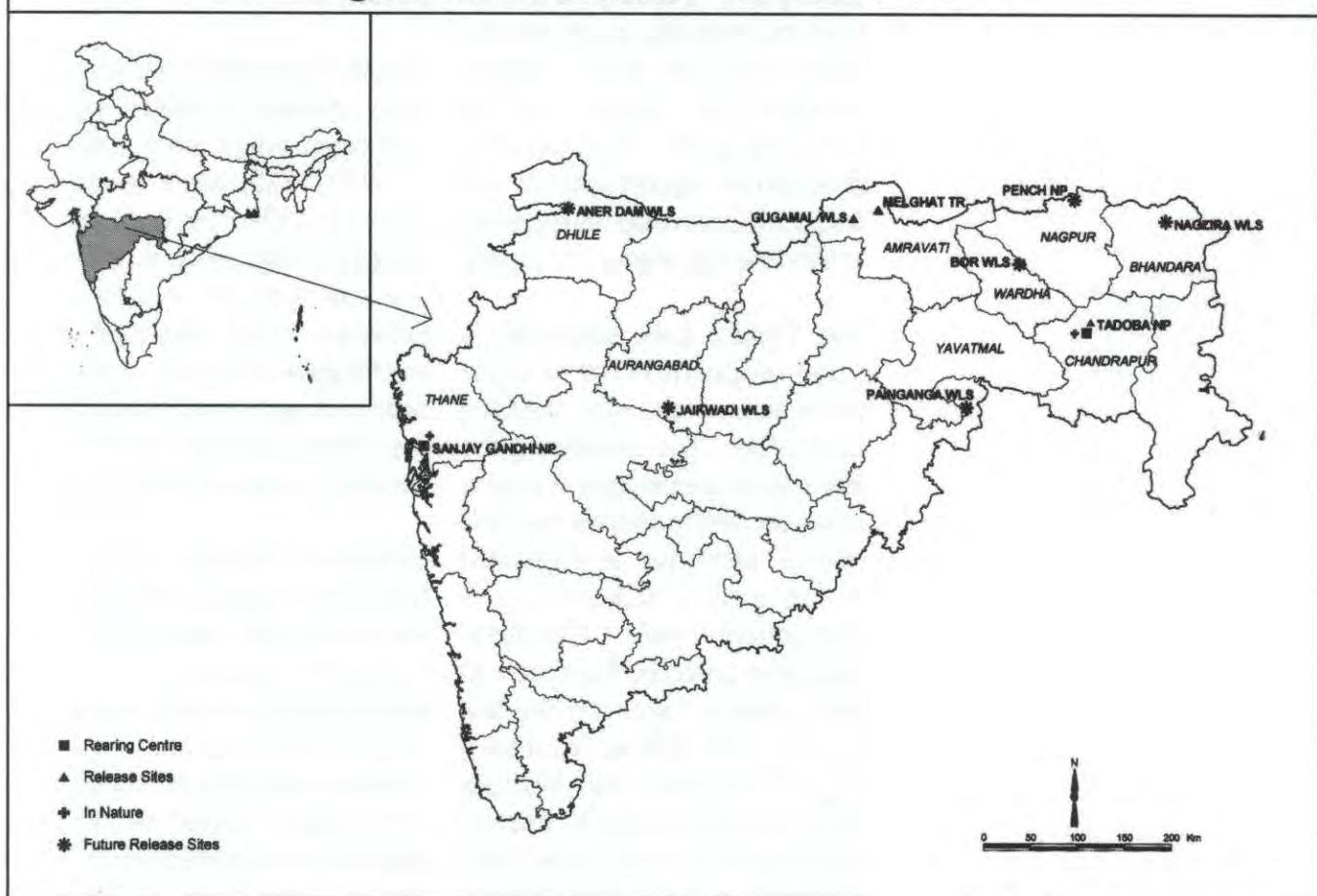
The largescale release of the mugger crocodiles into Neyyar reservoir, a part of the Neyyar Wildlife Sanctuary, where the water is shared by man and the wild animals has created some

conflicts. Most of the people who become victims of the crocodile attack belong to the localities like Mayam, Amboori, Thumbichikkadavu, Karimankulam, Puravimala, etc. In the Trivandrum district, where predominantly the tribals and the poor non-tribals reside, one woman lost her one arm in crocodile attack when she had come to the reservoir for water at sunset. She was paid compensation and also a job in the crocodile rearing centre. Another man and woman lost one finger each in crocodile attack. The domestic animals and, in one case, a wild baby elephant were also attacked by the mugger crocodiles in Neyyar Wildlife Sanctuary.

However, an analysis of the crocodile attacks reveals that the cases are negligible and could be averted by meaningful education and extension programmes on the ecology and the behaviour of the super predator. The Kerala Forest Department has started an education and extension programmes on wildlife, especially on crocodiles in the local areas around Neyyar Wildlife Sanctuary and the situation has now improved considerably. People have now started to appreciate the biological necessities of the mugger crocodiles.

The future

However, the abrupt winding up of the Indian Crocodile Conservation Project and its activities including the central government assistance after the first phase of programme, has created problems for successful

Figure 7 - Crocodiles in Maharashtra

Gandhi National Park, has a viable population of mugger, but this lake is under threat of pollution as also heavy human interference. Vihar and Tulsi lakes, within Sanjay Gandhi National Park, which are least disturbed, provide some chance for habitat protection and amelioration in the interest of crocodiles. These and the Tadoba lake in Tadoba National Park in Chandrapur district have been the only crocodile habitats in the state, which have received statutory protection. But, even in these areas, there have been no managerial inputs with specific emphasis on crocodile habitat improvement.

CROCODILE CONSERVATION EFFORTS
Tadoba Crocodile Rearing Centre
As a part of Government of India-FAO-UNDP sponsored Crocodile Conservation project, training was imparted to field staff in crocodile conservation and management, and two crocodile breeding centres were established. The first centre was established in Tadoba National Park in 1977, with 21 hatchlings of marsh crocodiles, brought from the Gir Sanctuary, Gujarat (Rajkondawar 1988). The centre includes a hatchery, a breeding pool, 16 pools for sub-adults and four pools for adult crocodiles; these pools are connected with a well-designed water supply and drainage system. Hatchlings were raised a large

successfully at the centre and subsequently gradually transferred from the hatchling pools to sub-adult pools, and then a limited number was shifted to the breeding pool. This process provided an opportunity for the field staff to develop an expertise in handling and rearing crocodiles.

The Tadoba Lake supported a small population of mugger crocodiles, which was breeding successfully. But considering the low survival percentage in nature, it was decided to adopt a "rear and release" technique, as postulated in the project (Choudhury & Choudhury 1986). Crocodile eggs were collected from the wild from Tadoba Lake, and the first batch of 12 hatchlings were born in 1979. In April 1980, fifty eggs were collected in a similar manner and the project authorities were successful in raising 29 hatchlings. This process continued till 1985.

Captive breeding at the centre added 82 hatchlings in 1986 and this was a major landmark in crocodile conservation efforts. In 1987 and 1988, the second and third batches comprising 70 and 53 hatchlings respectively, emerged from the eggs laid by the crocodiles in the breeding pool at the Tadoba crocodile rearing centre.

Sanjay Gandhi National Park Centre
The second crocodile breeding centre was established in Krishnagiri Upvan, Sanjay Gandhi National Park division in 1981, but it was not so successful and it is necessary to investigate the reasons for its failure. Non-

provision of sandy banks may possibly be one of the reasons.

The first two batches of hatchlings from artificially incubated eggs of wild origin, which were collected in 1979-1980, were ready for release in 1984. The first batch of eight hatchlings were supplied to Jijamata Upvan, Mumbai in February 1984, and then four hatchlings, with an average size of over 1m length, were released into the Tadoba lake for the first time, denoting a major achievement.

Till March 1992, one hundred and twenty six muggers were seeded out from this centre and this includes supplies to, and reintroductions in Erai and other waterbodies located close to Tadoba National Park, Tadoba and Pench lakes located within the respective protected areas, and also in forest pools of Melghat Tiger Reserve (Khawarey 1995). Release continued and 74 crocodiles were released in Tadoba lake and Erai dam sites only, as there were no other alternatives. The centre was then closed.

Reintroduction of crocodiles in and around Tadoba National Park
As reported above, out of more than 200 hatchlings successfully reared, a majority had to be released within and around Tadoba National Park only, because of administrative compulsions. Tadoba Lake is about 120 hectares only and though fish fingerlings are being released into the lake to improve fish stocking, sustainability of such

a large number of crocodiles on fishes is debatable.

A review of predation by crocodiles on wild herbivores indicates that crocodile is slowly emerging as a serious competitor to carnivores at the apex of the food chain in Tadoba National Park, i.e., tiger, panther and wild dogs. Crocodiles they are preying on wild boar, chital and sambar, and observations during the summer indicate that, crocodiles in Tadoba lake alone, are catching at least one animal almost every week.

With an average body-weight of 50kg, over a hundred crocodiles in and around Tadoba Lake mean over 5000kg of animal body-weight. Considering weekly food requirement to be 2% of the body-weight, about 100kg meat will be needed for their survival. If sufficient food is not available, intense competition for food will possibly result in migration and/or infighting for survival. A serious thinking is, therefore, necessary on limiting the number of crocodiles released in the protected area. As natural breeding of mugger is now taking place, even with low survival rates, there would be additions. Crocodile number thus need be kept in check. Picking up eggs regularly from Tadoba Lake banks for artificial hatching for translocation would be in order.

Reintroduction of crocodile in Melghat Tiger Reserve

Melghat Tiger Reserve encompasses the catchments of Khandu, Khapra, Sipna, Gadga and

Dolar rivers which are tributaries of river Tapi, in the Melghat and Chikhaldara Talukas of Amravati district. The project areas merely touch the river Tapi near Rangubeli, but the project itself does not include river Tapi. Literature review as also local enquiry reveal that the river Tapi used to harbour crocodiles (Dunbar Brander, 1971) but because of habitat destruction and excessive fishing, there are no crocodiles anymore within the areas encompassed by the Project Tiger Melghat itself. Because of possible human-crocodile conflict, the crocodiles could not be released directly into the river Tapi or its tributaries outside the tiger reserve. Those portions of the tributaries, which have perennial waterpools, within the tiger reserve, however, offered a fair chance for their re-introduction.

In 1990-91, it was thought essential to include mugger alongwith the tiger, under the umbrella of Project Tiger. A critical survey of the perennial waterpools and potentials of pisci fauna therein indicated a fair chance of survival for mugger. Introduction of mugger directly into the river Tapi was ruled out on administrative grounds as it would be difficult to monitor their movements at subsequent stages. Crocodiles were re-introduced in a systematic manner in March 1990 and February 1991 in Siddu Kund in Gadga river near Dhakna and Hathikund in the Dolar river in the Gugamal National Park.

The first and second batches of

crocodiles released were of 1986 origin. The first batch included 2 males and 5 females and had an average size and weight of 1.3m and 10.5kg respectively. Introductions in 1991 comprised 3 males and 5 females, with an average length and weight of 1.4m and 13kg respectively.

The released have been monitored till today (1999). It has been seen that crocodiles have survived in Siddu Kund though there have been substantial movements up and down the river. Breeding was also noticed and few hatchlings seen in the Siddu Kund subsequently. The reintroductions, therefore, can be termed a success.

The introductions in Hathikund have stabilized, but there has been considerable movement downstream. At least one or two animals are seen in the lake and recently the Deputy Director, Project Tiger, observed a full-grown crocodile in the Dolar riverbed about 3km down stream of Hathikund. Because of protection provided by the project to the habitat, muggers will have a fair chance to survive here, still we have to watch for their survival as time passes. As the animals grow, they may find it difficult to sustain themselves in the limited permanent pools and may migrate downstream; and would mean re-stocking of river Tapi, with fully grown and well adapted animals in a subtle manner and without generating ill will.

Potential for future crocodile reintroduction

There are a number of potential sites for reintroduction in rivers Krishna, Tapi, Wainganga, Pranhita, Indravati and Godawari. However, there have been no takers of hatchlings for release back to nature. A fear of backlash on account of releases, has been and still is a serious deterrent to reintroduction even in the protected areas. All the major river systems are under heavy human use; fishermen consider crocodile introduction to be a serious threat to their interests.

With the expansion of protected areas network in recent past, and inclusion of large reservoirs therein, the chances for reintroduction of mugger have increased, e.g. Koyana, Chandoli, Dnyanganga, Katepurna, Jaikwadi, Bor, Aner dam Sanctuaries, Pench National Park, etc. If we are able to convince the authorities incharge of hydel and irrigation projects and the fishermen's lobby that crocodiles are not a serious menace to their interests, the large potential for crocodile conservation can be harnessed. In Figure 1, places of re-introduction have also been tentatively indicated.

Saltwater crocodile has not been reported from Maharashtra. However, the areas which have been identified for mangrove conservation, could possibly provide sites for ex-situ conservation of this important crocodilian species. Potential sites for conserving mangroves and it is

proposed to launch serious efforts for conservation of these sites & possibly, there could be scope for 'ex-situ' conservation of *Crocodylus porosus* in one of these areas, if required.

Discussions and recommendations
Based on the foregoing information, it is surmised that crocodiles can be bred easily by collecting eggs and hatching them artificially under controlled conditions. Under protection, the hatchlings have better survival rates and the entire process of raising hatchlings is relatively simple. Since the food requirements of crocodiles are limited, rearing of hatchlings and sub-adults is easy. The adaptive and ectothermic nature of crocodiles enables them to adjust themselves easily even to difficult conditions.

The juvenile size of about 1m in length appears to be most suitable for release, as the chances of survival then are excellent in suitable habitat, where food and shelter is available. As in the case of Melghat, reintroduced crocodiles survived easily even in small water rivers. Individual crocodiles may occupy small pools which can sustain them while other individuals may migrate to occupy suitable habitats elsewhere. For this, they may cover even long distances of 5-10km downstream.

Serious impediments to *in-situ* crocodile conservation in Maharashtra are non-availability of suitable habitats free from human

interference and general opposition to reintroduction because of the prejudiced mindset of the people.

The role of crocodiles in the aquatic eco-system has not been properly understood and therefore, erroneous views that long-term conservation of crocodiles,

It is, therefore, necessary to carry out a detailed survey of existing nesting and the potential sites need to be identified for according strict protection during nesting and hatching period. For reintroduction, it is necessary to identify new sites suitable for reintroduction and educate local inhabitants so as to remove their misapprehensions and gain their support. It is also essential to evolve measures which will harmonise the interests of crocodile conservation with harvesting of aquatic resources by fishermen.

Taking into account the ground realities, *in-situ* conservation through protection to the existing habitat is a difficult proposition. Waterbodies within protected area would be the only viable proposition. However, such sites are limited. As artificial breeding of crocodiles is relatively easy, bold approach of allowing crocodile farming as a viable economic proposition in the private sector, be examined seriously.

References

BRANDER, DUNBAR (1982) -
Wild animals in Central India.

KHawarey, KN (1995) -
Crocodile Breeding centre at
Tadoba. *Tiger Paper* 22 (3): 15-
16.

CHOUDHURY BC and S
CHOUDHURI (1986) - Lessons
from Crocodile Reintroduction
Project in India. *Indian Forester*, 112
(10): 881 – 889

RAJKONDAWAR PL (1988) -
"Mugger Prajanan Kendra",
Tadoba, *Tadoba National Park*,
Chandrapur, Maharashtra..

Status of Mugger and its Conservation Problems in Gujarat

V Vijaya Kumar, Raju Vyas
and BC Choudhury

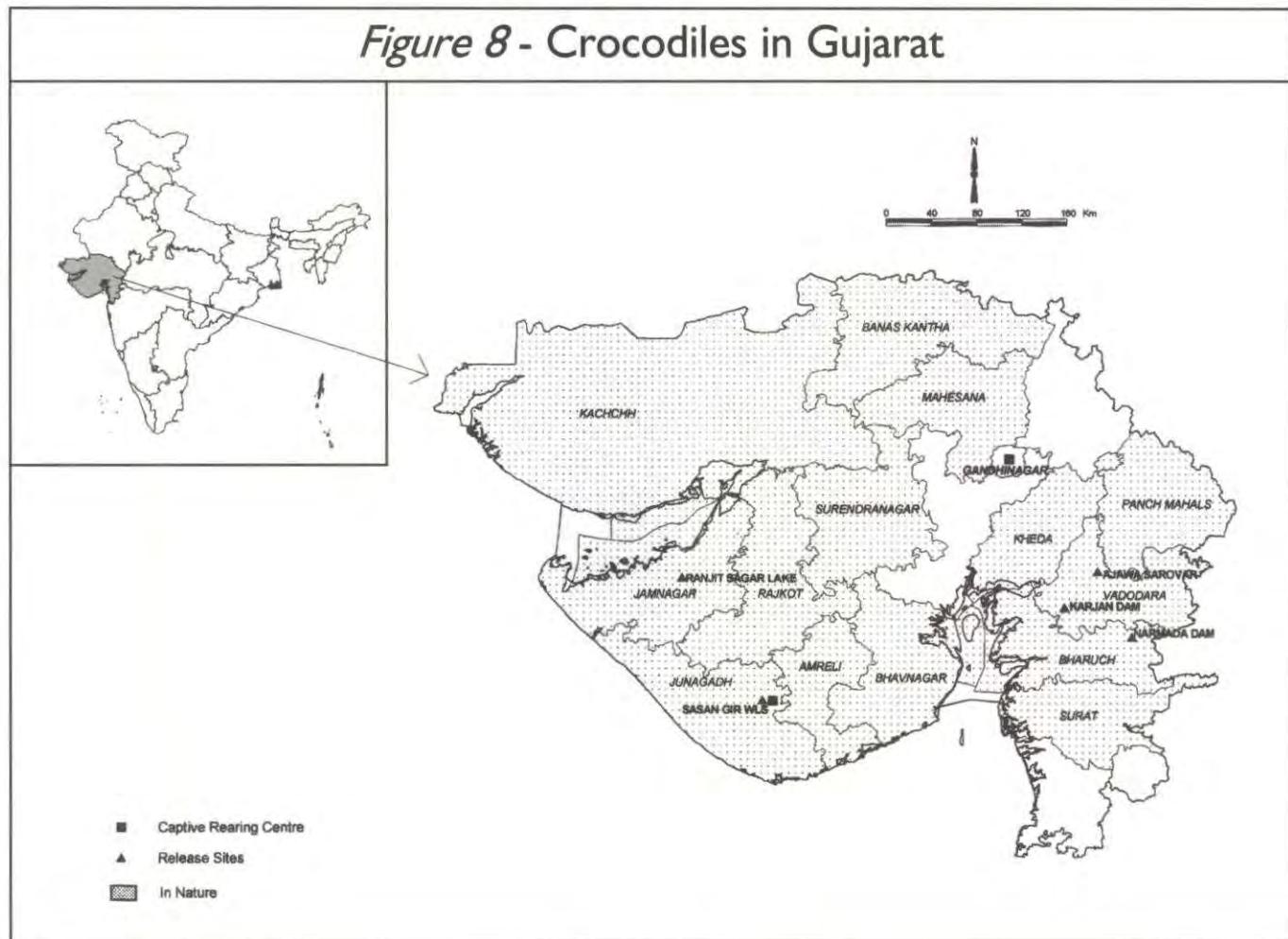
THE MUGGER (*Crocodylus palustris*) has the widest distributional range compared to any of the Asian freshwater crocodilian species (Whitaker and Whitaker 1989). It is a highly adaptable species, occupying a variety of habitats including hill streams, large manmade reservoirs, seasonal tanks, large rivers and small pools in the wilderness and also irrigation channels.

During the early 20th century, mugger were found commonly all over Gujarat, with fairly good populations in major rivers such as Narmada, Tapi and Mahi of south Gujarat and Watrak in central Gujarat. The Watrak river at Barsan Baroda, 50 km away from Ahmedabad, had the highest concentration with 50-75 mugger at every five kilometres (Acharya, 1949). Earlier, McCann (1938) had reported the presence of mugger only in the Banas river of north Gujarat region, while few muggers also existed in the river Sabarmati and in some of the village tanks in the region (VC Soni, pers. com.).

In 1975, a preliminary survey of mugger was conducted in Gir National Park by Joseph et.al.

(1975). Subsequently, Whitaker too conducted a survey and reported the mugger population in Gir forest, particularly at Hiran dam (also known as Kamelashwar lake), to be 51 (Whitaker 1978) with at least 15 nesting females. Rashid (1978) stated the wild mugger population in the state to be around 500, with a largest concentration of 200 mugger in Hiran lake and scattered smaller populations of less than 50 individuals in rivers such as Saraswati, Banganga and Ranjitsagar lake in the Saurashtra region. Oza (1975) reported that Ajawa reservoir had more than 100 crocodiles during the early 1960's. Today, the mugger population in this reservoir is around 50.

However, most of these statements are not based on appropriate survey. In fact, all the earlier surveys (except Acharya 1949) were possibly restricted to the Gir protected area, and none were done on a regular basis. As such, with the exception of some reports on the Gir population, the real status of mugger in the state was not exactly known. But what was clear from the reports during the period 1949-1979 was that the

Figure 8 - Crocodiles in Gujarat

distribution and population of mugger in the state had depleted considerably and that the species was critically endangered. This was mainly due to changes in the fishing methods, hunting and habitat destruction. It had locally become extinct from the Dang district, from where it was last reported at Mulchand in 1954 (Daniel and Shull 1963).

Conservation efforts

The endangered status of the mugger in Gujarat urged the state government to adopt the Indian Crocodile Conservation Project in 1977, which involved the establishment of crocodile breeding and rearing stations. The first captive reared mugger release

was done in the Hiran lake (in Gir) on 15 May 1984.

Between 1984 and 1996, the Gujarat State Forest Department had released 973 mugger within the Gir protected area, which included 148 in Kamleshwar lake, 200 in Rawal dam, 264 in Singota dam, 294 in Machundri dam, 40 in Billiyard – Kankai, 25 in other small waterbodies and two in Jatardi river. Muggers from the Gir rearing centre were also released into the Ranjit Sagar lake, located in Jamnagar district of Saurashtra region, where 13 mugger (12 from the Sasan centre and one caught from the wild) were released in May 1989 (Source: Gujarat State Forest Department). Besides, 27

muggers caught from the wild in Bharuch, Kheda, Surat and Vadodara districts in south Gujarat (Vyas 1994) were released in the Narmada dam (14 mugger), Karjan dam (5 mugger) and Ajawa Sarovar (8 mugger).

Impasse in crocodile conservation

As a result of efficient captive breeding programme, by 1995-96, there were about 289 mugger in 10 captive centres in the state. In fact, the stocks at the various rearing centres face a crisis of overcrowding and, consequently, inadequate care. Non-identification of new release sites other than the Gir protected area and the national policy prohibiting any option of commercial use of captive-bred crocodiles, have led to repeated stocking of mugger in the same location. Moreover, the waterbodies where mugger have been released are subjected to severe fluctuations in water level between the monsoon and summer seasons, particularly due to use of water for irrigation purposes. These constraints and problems have resulted in unwanted effects such as cannibalism, emigration and predation during dry periods (Vijay Kumar and Choudhury, 1994).

Thus, the main objective of the conservation project, i.e., to build up the depleted population, suffered due to non identification of new suitable mugger habitats other than Gir for future restocking and a dearth of information on the existence of wild mugger and the survival status of the released mugger in the

state. A general feeling that Indian crocodiles were now safe from extinction also led to easing down of the efforts.

A status survey in mid-90's

In response to these such issues, a survey of mugger in the state was carried (with the support of Fauna and Flora Preservation Society, U.K.) between March 1995 and August 1996. The objectives of the survey were,

- 1) to know the current distribution and status of mugger in Gujarat.
- 2) to gather information on the survival and dispersal of the released stocks and the factors governing them,
- 3) to identify and assess the feasibility of new sites for future reintroduction, and
- 4) to prepare a management action plan for the conservation and management of the species in the state.

For the survey, the state was divided into four major regions, as follows :

Kachchh - the largest district in the state (45652 km^2 or 24% of the state area), which fell in the arid tract;

Saurashtra - Rajkot, Jamnagar, Surendranagar, Junagadh (Gir forest), Amreli and Bhavnagar districts;

North Gujarat - Banaskantha, Mehsana, Sabarkantha and

Ahmedabad (including Gandhinagar) districts; and

South Gujarat - Kheda, Panchmahal, Vadodara, Bharuch, Surat, Valsad and Dangs districts.

Several methods were used to compile information on the distribution and status of mugger. The larger geographical area of the state ($1,96,024 \text{ km}^2$) with the presence of innumerable number of rivers, rivulets, reservoirs and tanks, did not permit us to carry out an elaborate census of the complete watercourse in the state. However, detailed site-specific census was carried out in waterbodies where from information on presence of mugger was obtained.

Survey results

During the study period, a total of 149 waterbodies, including 14 major dams, 69 medium dams and 66 other waterbodies such as minor dams, lakes, village tanks and 42 locations (each location measures about 5 – 10 km stretch) in 21 rivers were surveyed. Various pressures existed in these waterbodies - 101 were used for irrigation, 8 major dams for generating hydropower, 49 for fishing and 31 for domestic/drinking water purposes. Further, 40 water bodies were reported to be dry during the drought years, which is a common phenomenon in Kachchh and Saurashtra regions of the state.

Of the 18 district surveyed, there was information on the existence of mugger in 52 waterbodies and

10 rivers in 14 districts (Table 1). However, direct sightings of the wild mugger were recorded only in 25 waterbodies and six rivers in six districts - Amreli, Junagarh, Kachchh, Kheda, Panchmahal and Vadodara. Indirect evidences confirmed the existence of mugger in Bharuch and Surendranagar districts. In Ahmedabad, Banaskantha, Bhavnagar, Rajkot, Jamnagar, Sabarkantha, Surat, Mehsana and Valsad districts its existence was considered highly doubtful, whereas, location information and reports confirmed its local extinction from the Dangs district.

The total number of mugger recorded during the survey was 429, which included 368 adults (>6 ft), 44 sub adults (4 to <6 ft), six juveniles (1.5 to <4 ft) and 11 hatchlings. However, indirect evidences and local reports supported the existence of at least 1653 mugger in Gujarat, of which 1013 (from Sasan and wild caught) were released into various localities of the state. Maximum population was recorded in Junagadh district (306 mugger) followed by Kachchh district (94 : 11 hatchlings and 83 non-hatchlings).

Adults account for 88% of the non-hatchlings. The population structure of mugger mentioned in the results is based, on size structure rather than age structure. Due to high mortality that occurs in hatchlings, their percent may vary greatly within a given population in a short period of time. Hence, the data on

Table 1
Status of mugger in Gujarat in the mid-90's

Region	Mugger	
District	Reported	Recorded
Kachchh		
Kachchh	186	94
Saurashtra		
Amreli	7	5
Bhavnagar	2	0
Jamnagar	18	0
Junagarh	1272	306
Rajkot	1	0
Surendranagar	8	0
South Gujarat		
Bharuch	51	0
Kheda	11	8
Panchmahal	50	2
Vadodara	37	14
Surat	?	0
North Gujarat		
Banaskantha	7	0
Mehsana	3	0
Total	1653	429

Table 2
Percent Sightings of Small Size Class Muggers

Region Non-hatchlings	Number of Juveniles & Sub-Adults	Number of	Percent
Kachchh	83	19	22.9
Saurashtra	311	29	9.3
South Gujarat	24	2	8.3
North Gujarat	0	0	0
Gujarat	418	50	11.9

hatchlings were eliminated from the population analysis.

Implications on population

Among the non-hatchlings, the percent sightings of juvenile and sub-adults, recruitment into the population was recorded high (22.9%) in the Kachchh region whereas it decreased to 9.3% and 8.3 % in the Saurashtra and South Gujarat regions respectively (*Table 2*). The record of 12% (n=50) of the sub-adults indicates a low natural recruitment in the state and this could be due to high loss in the egg and hatchling stages. Predation and environmental factors are the two major causes for the loss of eggs during the post hatching periods (Thorbjanarsan, 1989) and hatchlings, which tend to reduce the number of hatchling entering into adult classes in the wild.

Very few sightings of the juvenile class and also of sub-adults indicated that high crocodile density might have triggered density dependent population control which may have led to complete exclusion of smaller individuals from the main population or mortality via mechanisms such as cannibalism.

Schmidt (1924) reported similar observation at Honduras, where he recorded a high crocodile density with a total absence of small juveniles. Juvenile mortality becomes a bottleneck to population growth (Hutton, 1984). Added to this, the spatial segregation of crocodiles by size class may represent a difference in the physical habitat requirements of different sized crocodile or it may reflect social factors and agnostic encounters between size classes (Messel et al. 1984). These could be some of the possible reasons for the less sighting of small size class mugger in the state.

Though mugger were generally reported as a friendly and peaceful animal for both cattle and man, the human-livestock-crocodile conflicts were escalating due to increased pressure on mugger habitats. Between 1991 and 1996, there were 10 cases reported of attacks on human by adult male mugger (three each in Kachchh and Saurashtra and four in the south Gujarat region) during the period. Of these, nine attacks occurred between May and July when the water level was very low.

Conservation and management
Past debates on crocodile conservation and management focused largely on the population within the protected areas, which provide favorable reserves and virtual absence of intensive agriculture. These features add up to a conservation equation for protected area mugger populations, which is very different from the populations that exist outside. There were a good number of mugger recorded outside the protected areas in Kachchh, Saurashtra and the south Gujarat region.

Crocodile conservation is not a simple case of preservation. Over the year, there have been major changes in the types of threats to mugger. The early actions, when mugger habitats were still relatively undisturbed, were almost entirely concerned with limiting their killing. Now, the most invidious threat to mugger is not excessive killing, but disruption of their habitat, because of which most of the species may never regain their historical numbers.

There are other complex challenges to crocodile conservation as well. The Kachchh region is entirely an arid tract where droughts are a recurring phenomenon whereas south Gujarat region is a heavy rainfall tract. As such, it is essential to develop a management strategy specific to each region which would be sensitive to regional variations in habitat quality and conservation potential, and also emphasizes on resources in

areas of maximum benefit to statewide crocodile conservation.

The management plan also needs to recognize the social dimension to the problem. Agriculture puts an enormous pressure through direct competition with crocodiles. Use of reservoir water for irrigation purposes during February and June leads to a decrease in water level, which coincides with the crocodile egg laying and hatching period, and this causes tremendous nest losses. There is no denying the paramount importance of agricultural development and food production for the ever-increasing human population. However, it should be also noted that surface water irrigation, the oldest form of irrigation, requires large quantities of water, as the losses in the form of infiltration, evaporation etc. are enormous. As such, water extraction for irrigation from mugger habitats needs to be regulated during the breeding season through application of modern techniques like sprinkler, drip irrigation etc.

Moreover, the sharing waterways by people and crocodiles give rise to conflicts also need to be resolved, since such conflicts create a significant impact on the survival of mugger in the unprotected areas. The success of any conservation programmes is strongly dependent on the support and active participation of local people and, as such, managing people-crocodile interface becomes essential, which some of the earlier debates and

plans have ignored or trivialized. Concrete measures must be taken to avoid potentially disastrous consequences of human deaths resulting from crocodile attack where sharing of common water bodies by mugger and human exists. A high priority should be given to the interests and needs of the local people and measures be taken to provide them alternative resources where possible.

A complete protection to crocodiles throughout state is at present an impractical consideration, because most of these are found in remote areas with no or little law-enforcement. The recovery of mugger in many parts of its historical range will be very difficult, because of heavy human usage, the antipathy of man towards crocodiles, as well as human and livestock population expansion and other associated factors that cause habitat destruction.

An education programme needs to be designed to eliminate apprehensive beliefs about dangerous interactions between people and crocodiles throughout the state but more particularly in areas where the restocking of crocodiles is contemplated. However, at the same time, the 'problem' crocodiles (broadly defined as those attacking human and livestock or residing in human habitations, where their presence constitutes a risk to people and livestock) from unprotected areas must be identified and removed from the wild and assigned to

captive centres which would enhance the genetic viability of the captive stock.

But it is very important to avoid restocking in high crocodile density areas, because it results in an overlap in habitat use by different size class, which may lead to cannibalism and out migration of smaller size classes. Based on the hydrological characteristics of the water body (during dry and wet periods), the restocking has to be regulated. Therefore, it is suggested to stop further restocking within the Gir sanctuary. Monitoring the major mugger population area is very essential to understand the effects of the implementation of the project. The formulation of state level Crocodile Monitoring Committee (CMC) by subject experts, Forest Department officials and NGO's would be of great help in this direction. It would also enhance the information base, help in prioritizing site specific management issues and evolving appropriate strategies.

References

ACHARYA, H (1949) - List of reptiles from Gujarat state. *Prakaruti (A Gujarat Journal)* 8: 158 - 178.

CHAVAN, SA (1979) - Distribution and conservation of crocodiles in and around Gir wildlife sanctuary. *Indian J. of Forestry* 2 (3) 266-268.

DANIEL, JC and EM SHULL (1963) - List of the reptiles and

Crocodile rearing centres



Gharial, Kukrail (Uttar Pradesh)

Mugger, Hyderabad (Andhra Pradesh)



Saltwater crocodile, Dangmal (Orissa)

Management and research



Cloacal probing for sexing a crocodile



Wild mugger egg collection, Gir (Gujarat)



Blood sample collection

Release and monitor



Gharial release
Satkosha Gorge (Orissa)



Mugger release
Krishnagiri (Tamil Nadu)



Post-release monitoring
Bhitarkanika (Orissa)

Status of Crocodilians in Protected Areas of Rajasthan

KK Sharma, Daulat Singh
and BC Choudhury

THE SEMI-ARID STATE OF Gujarat harbours two species of crocodilians; the Gangetic Gharial, (*Gavialis gangeticus*) and the mugger crocodile, (*Crocodylus palustris*). Gharial is found in the Chambal and other perennial tributaries of Ganges and the mugger crocodile is practically present in all kinds of fresh water areas in the state, although in very small numbers. Being an arid state, the state is endowed with numerous man-made lakes which support the mugger crocodile. However, as is the case in most of its distribution zone, the crocodilians were a persecuted lot till the adoption of the Wildlife (Protection) Act 1972, when all the three species of Indian Crocodilian were placed in Schedule I of the Act. The present situation of crocodilians can be summarized as being safe in the Protected Areas of Rajasthan.

The State of Rajasthan was involved in the countrywide crocodile programme in the late 1970's which resulted in creation of the National Chambal Sanctuary, a significant portion of which remains within the Rajasthan state boundary. Reintroduction of Gharial and mugger crocodiles into

the wild in the Protected Areas of Rajasthan perhaps dates back to late 1960's. According to late Shri Kailash Sankbala (pers. comm.), captive breed mugger crocodiles have been introduced into the lakes of Ranthambore Tiger Reserve. Incidentally Jaipur Zoo of Rajasthan was one of the first zoo in the country to breed mugger crocodiles in captivity and in recent years have also been breeding Gharial in captivity.

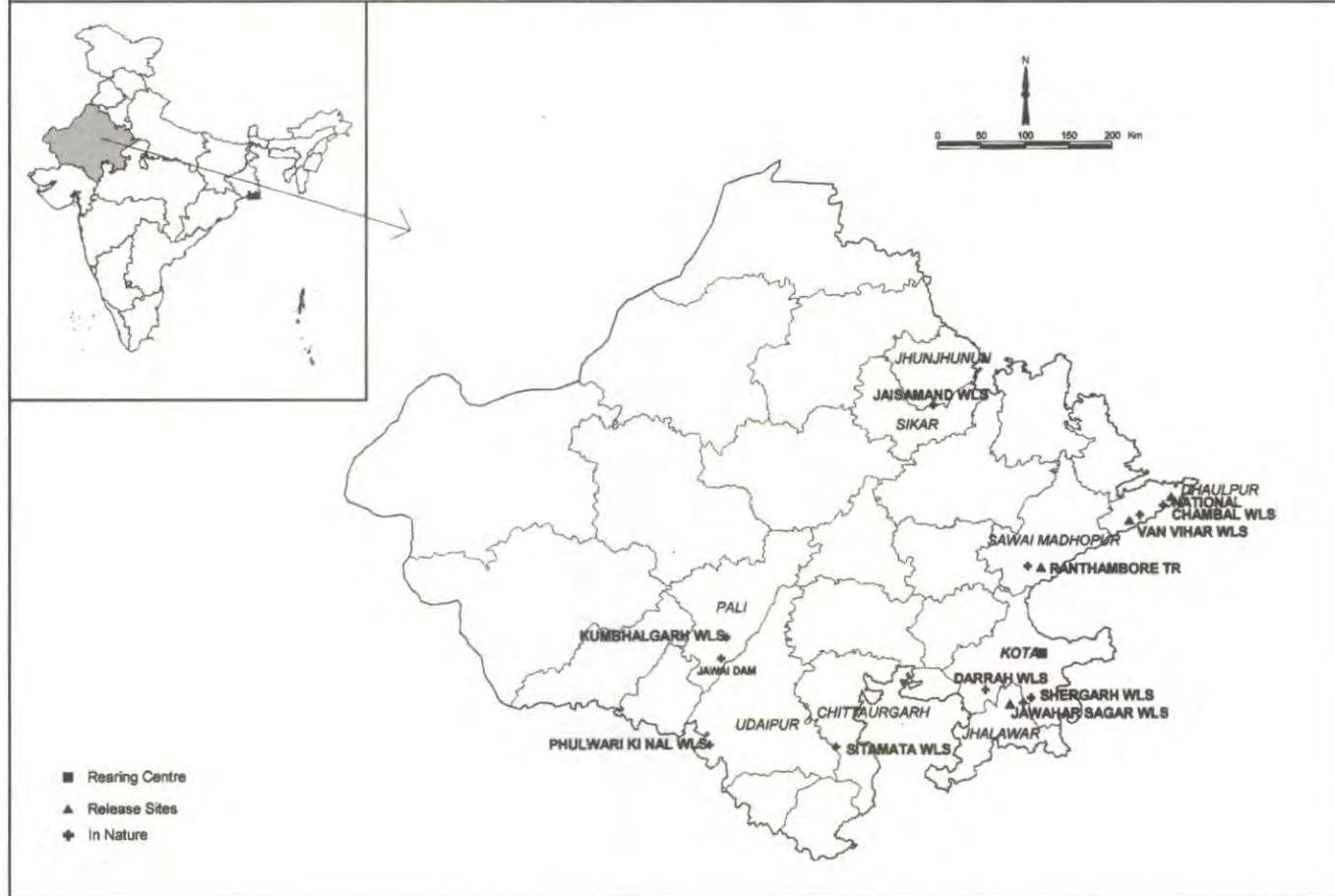
Early Crocodile Conservation Programmes in Rajasthan :

The state set up a small Gharial rearing station at Kota but had to stop that activity soon, once the state of Uttar Pradesh and Madhya Pradesh set-up larger facilities to rear crocodilian for release into the wild in Chambal river. Thereafter, the state has more or less resorted to protection of crocodilians in the wild and reintroducing zoo-bred stocks into the wild.

The Future

With mugger breeding in all zoological parks in the state and some gharial population in the wild, there is a need to work out a long term strategy for crocodilians. Indian crocodilians have been a

Figure 9 - Crocodiles in Rajasthan



sought after wild animal by wildlife tourists. Some of the Protected Areas in Rajasthan will benefit through eco-tourism involving crocodilian species – particularly

Chambal, Ranthambore and Jawai Reservoir closed area. This will also ensure proper monitoring of crocodile populations in the state.

Crocodilians in protected areas of Rajasthan		
Protected Area	District	Species
Ranthambhore National Park	Sawai Madhopur	Mugger N&R (180-200)
Kumbhalgarh Wildlife Sanctuary	Udaipur	Mugger N (<10)
Phulwari ke Nal Wildlife Sanctuary	Udaipur	Mugger N (<10)
Sitamata Wildlife Sanctuary	Chittorgarh, Udaipur	Mugger (>50)
National Chambal Wildlife Sanctuary	Kota, Sawai Madhopur, Bundi Dholpur, Karauli	Mugger and gharial N&R (<1200)
Darrah Wildlife Sanctuary	Kota, Jhalawar	Mugger N (<10)
Jawahar Sagar Wildlife Sanctuary	Bundi, Kota, Chittorgarh	Mugger and gharial N&R (<20)
Shergarh Wildlife Sanctuary	Baran	Mugger N (>50)
Jaisamand Wildlife Sanctuary	Udaipur	Mugger N (<10)
Jawai Reservoir	Pali	Mugger N&R (>20)
Van Vihar Wildlife Sanctuary	Dholpur	Mugger N&R (>10)

N = Natural population

R = Released population

Status and Conservation of Crocodiles in Madhya Pradesh : An Update

RJ RAO

MADHYA PRADESH IS ONE OF the biggest states in India, covering an area of around 450,000sq km. It has large water resources, with its total length of river spread being about 20,000 km (Farqui and Verma, 1993), wherein two crocodilian species, the gharial (*Gavialis gangeticus*) and mugger (*Crocodylus palustris*) are available. The former is present in the Ganga river system but only within protected areas, while the latter can be seen in the perennial rivers, freshwater lakes, streams, reservoirs, swamps and marshes. (See Tables 1 and 2.)

The populations level of these species is very low throughout the range in the state. The crocodile populations outside the protected areas are threatened by hunting and habitat destruction. Most fishermen reported that they do not kill crocodiles purposely, but these are occasionally captured accidentally in the fishing nets.

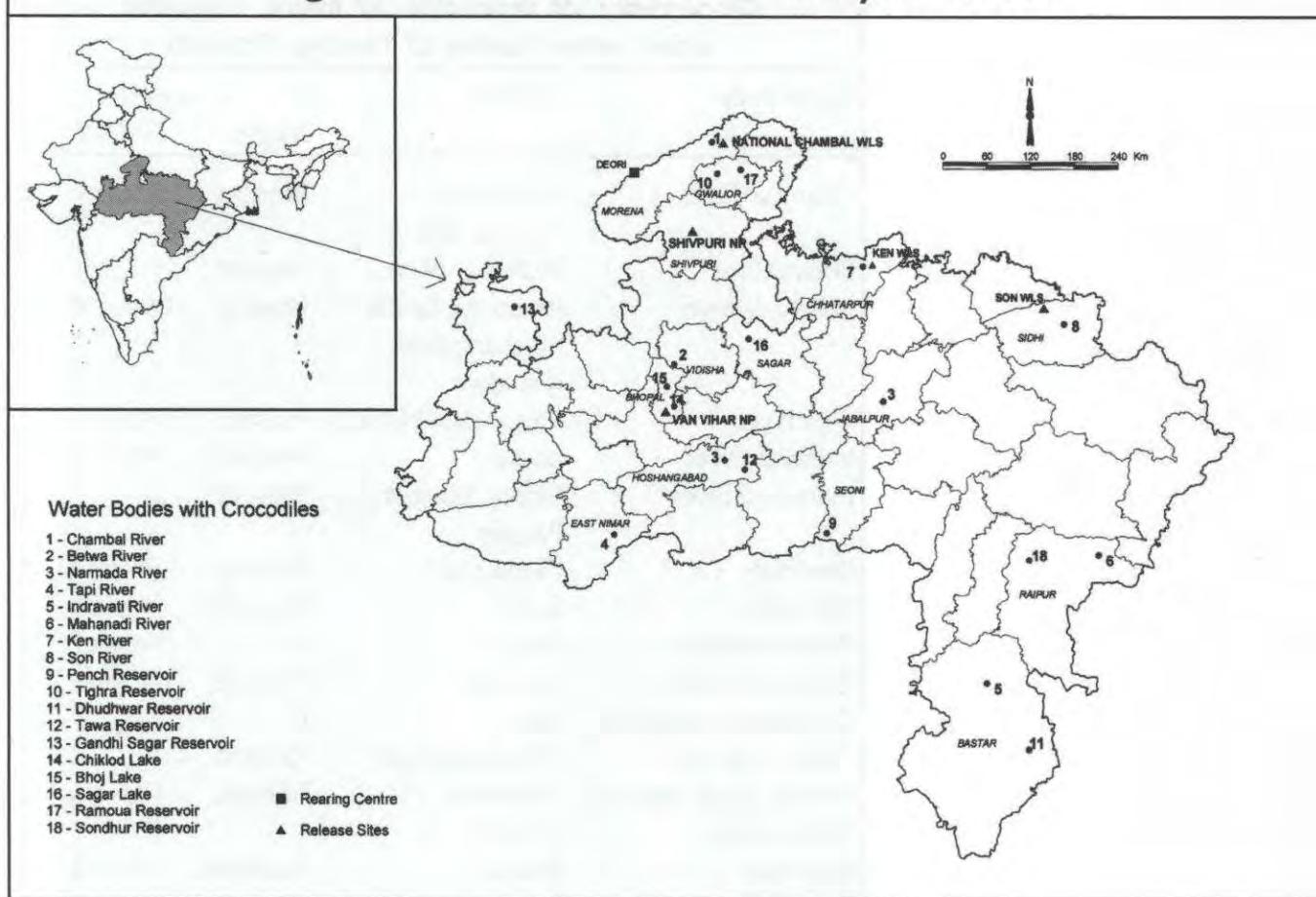
Conservation measures

Concerned at the dwindling crocodile populations as a result of large-scale killings because of fear of the animal or conflict, or because of its high trade value, the MP state government undertook a rehabilitation programme for the

gharial under the Crocodile Project. Important crocodilian habitats were identified and given protection. Three sanctuaries were specially created as part of the programme – (1) National Chambal Sanctuary; (2) Ken Gharial Sanctuary; and (3) Son Gharial Sanctuary. While the main focus of management in these protected areas was to provide protection to crocodiles, other aquatic animals too have received incidental protection (Rao, et al. 1995).

Crocodile Rehabilitation

Rehabilitation of crocodiles was started in 1978 through a 'grow and release' technique. A crocodile captive rearing centre has been established at village Deori, in the Morena district in 1980. The following year, gharial nests were located at Baroli and eggs from one of the nests transferred to Deori for artificial incubation (Rao and Sharma, 1986). In 1986, ten captive reared gharial from the Deori centre were released in the Van Vihar National Park at Bhopal. The captive rearing programme continued up to 1995 and in all 900 wild-laid gharial eggs were collected. Hatchlings emerged

Figure 10 - Crocodiles in Madhya Pradesh

from the eggs were carefully reared at the Centre and approximately 250 grown animals were released in Chambal, Ken and Son rivers.

Concurrently, mugger was also reared in captivity. In 1987, a clutch of mugger eggs was collected from the Chambal river. These were also transferred to the Deori centre, and subsequently the grown up young released in the wild. A total of 25 mugger was released in the Chandpata lake inside the Madhav National Park, Shivpuri. One pair of mugger from the Jaipur Zoo was translocated to the Van Vihar National Park in 1988. Captive reared gharial and mugger have also been given to various zoos (Table 3).

Population monitoring

Monitoring of the released crocodiles in different sanctuaries has been taken up to evaluate the success of the rehabilitation programmes. The current status of crocodiles in different crocodile sanctuaries in the State is shown in Table 4. The 1995-96 census revealed a recovery in the gharial population in the Chambal river in the last decade from an earlier declining status (current population 1214 with adult male to female ration being 21:77), and a need to release more gharial in to the Son river. A total of 75 gharial nests in 21 nesting sites were located in the 400 km of the National Chambal Sanctuary.

Water body	Districts	Crocodiles	
		Mugger	Gharial
Chambal River	Mandasaur, Morena, Bhind	Present	Present
Betwa River	Vidhisha, Bhoa;	Present	?
Narmada River	Jabalpur, Mandla, Hoshangabad, Khandwa	Present	Absent
Tapi River	Detul, East Nimach	Present	Absent
Indravati River	Bastar	Present	Absent
Mahanadi River	Raipur, Bilaspur, Raigarh	Present	?
Ken River	Chatarpur	Present	Present
Son River	Sidhi	Present	Present
Pench reservoir	Pench	?	Absent
Tighra reservoir	Gwalior	Present	Absent
Dhudhawar reservoir	Bastar	?	?
Tawa reservoir	Houshangabad	Present	?
Gandhi Sagar reservoir	Mandsaur	Present	Present
Chklod lake	Bhopal	?	?
Bhoj lake	Bhopal	Reported	Absent
Sagar lake	Sagar	Absent	Absent
Ramoua reservoir	Gwalior	Reported	Absent
Sondhur reservoir	Raipur	?	Absent

Protected area waterbody	River/	Gharial	Mugger
National Chambal Sanctuary	Chambal river	+	+
Son Gharial Sanctuary	Son river	+	+
Ken Gharial Sanctuary	Ken river	+	+
Madhav National Park	Chandpata lake	-	+
Narsimgarh Wildlife Sanctuary	Narsimgarh lake	-	+
Kuno Palpur Sanctuary	Kuno river	+	+
Indravati National Park	Indravati river	-	+

+Yes, - No

Table 3
Crocodiles in ex-situ facilities

Name of the Zoo	Gharial	Mugger
Bhopal Zoo	10	2
Indore Zoo	?	?
Bhilai Zoo	-	2
Gwalior Zoo	4	4

Table 4
**Current crocodile population
in the protected areas in Madhya Pradesh**

Protected Area	Mugger	Gharial
National Chambal Sanctuary	120	1214
Son Gharial Sanctuary	11	35
Ken Gharial Sanctuary	3	22

Conclusion

Madhya Pradesh harbours the best remaining populations of gharial in the country, with three sanctuaries specially created for its conservation. Although, at present it is breeding only in the Chambal river only, but now with the release of a male in the Son river, it is expected that after some years the species will start breeding in that river as well. There are some minor reports of crocodile-human conflicts in different parts of the state, the overall situation for crocodile conservation is encouraging.

The recommendations of the workshop on gharial PHVA (Rao et. al. 1995) should be implemented immediately. The rehabilitation programmes should be continued for some more years. Monitoring of released crocodiles has to be continued by the field staff of the protected areas. Research studies on

crocodile conservation also need to be encouraged for the better management of crocodiles in the Madhya Pradesh.

References

FARUGUI AM and VERMA, RN (1993) - Development of fisheries in Madhya Pradesh. National Seminar on Conservation and Development of Aquatic Resources. December 1993, Bhopal

RAO, R, AND RK SHARMA (1986) - Gharial rehabilitation in Madhya Pradesh, India. *Tigerpaper*, 13(1):2-4.

RAO, RJ, D BASU, SM HASAN, BB SHARMA, S MOLUR and S WALKER (1995) - Population and Habitat Viability Assessment (PHVA) for Gharial. Workshop report, July 1995

Survey of Gharial in National Chambal Sanctuary - 1993-97

RK Sharma

THE CHAMBAL RIVER WAS declared a Gharial Sanctuary (location : $25^{\circ} 30'N$ - $26^{\circ} 52'N$ and $76^{\circ} 28'$ - $79^{\circ} 0'E$) in 1978-79 under the Crocodile Project with the aim to provide a fully protected habitat for the conservation and propagation of the gharial and other aquatic animals. An area of about 425km of the Chambal river from Pali (Chambal-Parvati confluence) to Bhare (Chambal-Yamuna confluence) is now under the management of the National Chambal Sanctuary, which forms boundary between Rajasthan and Madhya Pradesh, and between Madhya Pradesh and Uttar Pradesh. The river finally joins the Yamuna near Etawah in Uttar Pradesh. (See Figure 10)

For proper management of a river it is very important to know its existing fauna. In order to assess the role of environmental changes in the distribution of species regular surveys and census of the gharial population in the National Chambal Sanctuary have been conducted since 1984 (1984-91 and 1993-98).

Methodology

As a follow-up to the earlier surveys conducted in 1984-1991

the entire stretch of the Chambal river under sanctuary status was annually surveyed in the winters (November – February) during the period 1993-1998, for gharial, mugger and other aquatic vertebrates animals. The surveys were conducted on a boat fitted with an out-board motor (40 HP) and also on foot. Field binocular was used for recording numbers and approximate size of the animals. All sightings were recorded on the field map sheets. Informal discussions were held with persons directly or indirectly involved in the affairs of sanctuary area. Table I below presents gharial counts made in the study area.

Observations and findings

1. In the 1993 survey, a total of 898 gharials in all sizes were sighted with a mean density of 2.11 gharial per km. Out of these, 186 were adults (20.71%), 305 sub-adults (33.96%), 141 hatchlings (15.70%) and 266 yearlings (29.62%).
2. The total number of gharials sighted in the 1994 survey was 1108 with a mean density of 2.6

Table - 1
Status and distribution of gharial in National Chambal Sanctuary - 1993-97

Year	Distance surveyed From	To	Total km	Hatchling <3ft	Yearling 3-4ft	Adults Over 10ft	Sub Adults 4-10ft	Total No. of gharial sighted
1993	Pali	Pachnada	425	141	266	186	305	898
1994	Pali	Bhare	415	172	316	202	418	1108
1995-96	Pali	Bhare	415	189	368	212	445	1214
1996-97	Pali	Bhare	415	232	322	226	459	1242

Table 2
Nesting survey of National Chambal Sanctuary - 1993-97

Head	Year				
	1993	1994	1995	1996	1997
Gharial Nest	64	68	75	77	81
Mugger Nest	8	8	9	11	12
Gharial eggs collected	102	80	-	-	-
	(MP)	(MP)			

gharial per km. The age-group distribution was - adult 18.23%, sub-adult 37.72%, hatchling 15.52% and yearling 28.51%.

- During the 1995-96 survey, 1214 gharial with a mean density of 2.8 gharial per km were counted. The age-group distribution was adult 17.48%, sub-adult 36.65%, hatchling 15.56% and yearlings 30.31 %.
- In 1996-97, the total number of gharials sighted in the survey was 1242, with a mean density of 2.9 gharial per km. The age-group distribution was adult 18.19%, sub-adults 36.95%, hatchling 18.67% and yearling 25.92%.

Gharial nest survey 1993-1997

In addition to the annual population surveys, summer surveys were also conducted to

locate gharial and mugger nests in the Chambal river (*Table 2*).

CONCLUSION

During 1993-1997, an increasing trend in the population density of gharial in the National Chambal Sanctuary can be marked. Although, the increase is not significant, it seems to be satisfactory. The percentage of yearlings in 1995-96 is high (30.31%) because about 80 yearlings were released from the Deori gharial rearing centre prior to the survey. From the nesting survey figures, it is also apparent that between 1993 and 1997, 17 new gharial females joined the breeding group. And though a large number of nests are located during the summer months, only a small percentage of hatchlings are seen the following winter. This could be attributed to the nest predation in the wild, dispersal and

loss of hatchlings following hatching due to predation, mortality and the monsoon floods.

It is, however, important to emphasize that such annual gharial nesting and population surveys are essential to determine the well being of perhaps one of the world's best crocodile rehabilitation projects.

References

Khan Z (1983) - Son gharial sanctuary : Summary plan and management. *Forest Department, Madhya Pradesh.*

SHARMA, RK, SANJAY SHARMA and R MATHUR (1995) - Wildlife Survey in Madhya Pradesh – II, Survey Report on Ken gharial sanctuary, *Journal of Freshwater Biology*, 7(1) : pp. 59-62.

SHARMA RK and SANJAY SHARMA (1997) - Wetland faunal survey of Son gharial sanctuary in Madhya Pradesh. *The Indian Forester*, Vol. 123, No. 10. pp.952-957.

SHARMA RK AND R MATHUR (1997) - Biodiversity in national Chambal Sanctuary, Status and strategies for management. *Annual Report to the Madhya Pradesh Council of Science and Technology*, Bhopal, mimeo 30 p.

Status of Gharial in Ken and Son Gharial Sanctuaries, Madhya Pradesh

RK Sharma, PK Choudhary
and D Basu

THE GHARIAL (*Gavialis gangeticus*) and mugger (*Crocodylus palustris*) have historically inhabited the rivers of the Gangetic system and may still occur or did till recent past in the Kali Sindh, Parvati, Chambal, Kunoo, Sindh, Ken and Son rivers.

In 1979, with the Madhya Pradesh Forest Department initiating a gharial and mugger rehabilitation programme, Chambal, Ken and Son rivers were protected as gharial sanctuaries. Other management measures for the species were also implemented in these rivers, such as physical enforcement of wildlife protection laws, banning of fishing and supplementation of wild gharial populations with captive reared animals. The crocodilians of these rivers have been periodically censused and surveyed.

This note presents the status of gharial in the Ken and Son gharial sanctuaries on the basis of these census and survey operations.

Ken gharial sanctuary

The Ken Gharial Sanctuary was notified in October 1981 and includes the 45km Long stretch of the Ken river from the Bariarpur irrigation barrage to Gumanganj/

Pancham nagar. This stretch of the river forms the border of Chhatarpur and Panna districts of Madhya Pradesh.

There are no easily traceable local or documented reports of the former occurrence of gharial in this stretch of the Ken river which flows between steep rocky banks interspersed in places with flat sandy riverbanks. The area was considered suitable for the management of gharial because of the river depth (max.>22m) and other available characteristics of ideal gharial habitat, such as sandy riverbanks and a fairly good fish population.

Gharial releases and monitoring survey

As already mentioned, no gharial occurred in this sanctuary prior to the reintroductions of captive reared animals in 1985. Since then, a total of 74 gharial have been released at a single location viz. Mohare Ghat in the sanctuary. As against the above reintroductions, the numbers of gharial counted in various years (Sharma et. al., 1995) is given in Table 1.

The 15 gharial seen in 1999 belonged to six spatially discrete

Releases and monitoring survey results of gharial in the Ken Gharial Sanctuary, MP		
Year	Gharial releases	Gharial counted in census
1985	10	-
1987	10	-
1993	10	-
1994	-	19
1995	15	-
1996	08	22
1997	01	-
1998	20	-
1999	-	15
Total	74	

groups, each separated from its adjacent group by a mean distance of 2.4km.

Break-up of size classes seen during the 1999 census is as follows :

Large adult males	Nil
Large adult females	03
Small adult females	03
Sub adults	Nil
Juveniles	05
Young below 1.2m.	04

If animals less than 1.2m in length seen during the 1999 census, as well the 20 gharial released in 1998 which belonged to same size class and constitute a transient size class of animals with low probability of residence within the sanctuary, are eliminated from an analysis of the status of gharial in the Ken gharial sanctuary, it will be seen that out of 54 gharial released in the sanctuary prior to 1998, 11 or 20.4% of gharial reintroduced in the sanctuary have been retained within the sanctuary limits. At least 6 or 3.24% of the gharial have

been non-resident adults availability of nesting sites, which constitute the main limiting factor in the carrying capacity of this sanctuary, indicates that the sanctuary can support a breeding population of 10 -15 females.

Thus, it can be said, that currently, only 40% of the sanctuary's estimated carrying capacity of gharial adults reside here. At the observed rate of retention of reintroduced gharial, i.e, 3-4%, at least an additional 200 - 250 gharial should be released in this sanctuary. It deserves to be mentioned that the census operations were conducted in early summer so the enumerations of gharial could be lower than that of numbers of gharial actually present. Special efforts to introduce male gharial in adequate numbers should be made, to ensure that the breeding requirements of the sanctuary's carrying capacity of females are fulfilled, and a healthy reserve population of both sexes also reside there.

Son gharial sanctuary

The Son gharial sanctuary was notified in September 1981 and includes the 161 km long stretch of the Son river from the Bhanwarsen/Bansagar dam to Piparghat. This stretch of the Son flows first along the border between Shahdol/Santna and then Shahdol/Sidhi districts and finally in the Sidhi district of Madhya Pradesh. The sanctuary also includes stretches of the Gopad and Banas rivers, totaling

Table 2
Possible population and census
results of gharial in the Son
Gharial Sanctuary, MP

Year	Gharial releases	Gharial counted in census
PSN*	13	-
1981	13	-
1985	30	-
1986	22	-
1988	20	-
1989	20	-
1994	-	32
1996	-	35
1997	01	-
Total	119	

*PSN - Prior to sanctuary notification

an additional 48km. Near the Bansagar dam site, the Son passes through a narrow gorge beyond which the river widens to 1km. At certain points, the river varies widely in depth from knee deep to 15-20 m.

Son gharial sanctuary

In a survey undertaken prior to the notification of the sanctuary, a total of 13 gharial varying in size between 2m and 5m were enumerated from six different sites within the sanctuary area (Khan 1993). Following the notification, 105 captive reared gharial of approximate lengths 1.5 - 2m. were reintroduced in the Son Gharial Sanctuary. The possible numbers of gharial living in the sanctuary as against the numbers observed in census surveys in the recent past (Sharma et al., 1997) are given in Table 2.

The 35 gharial seen in 1996

belonged to seven spatially discrete groups, each separated from an adjacent group by a mean distance of 20.8km.(7-55km).

The break-up of size classes seen during the census operations (i) prior to sanctuary notification (PSN) and (ii) in 1996 are as follows :

<u>(PSN)</u>				
<u>1996 Difference</u>				
Large adult males	Nil	Nil	Nil	
Large adult females	02	17	+15	
Small adult females	02	08	+06	
Sub adults	09	06	-03	
Juveniles	Nil	04	+04	
Young below 1.2m	Nil	Nil	Nil	

It may be surmised from the above figures that there has been an increase in the numbers of gharial in the Son sanctuary especially of the adult size classes. This is notwithstanding that in 1996, the census was undertaken in the month of March and a larger number may well have been enumerated in the preceding winter months. In addition to the 105 juveniles reintroduced into the sanctuary , there were 9 sub-adults residing in the sanctuary prior to the reintroductions. Of these 114 animals, 22 were accounted for during the 1996 census, indicating a gross retention rate of 19.3% for the reintroduced animals, and an increment rate of 18.4% in the population of adult females.

The density of gharial in the Son Gharial Sanctuary was found to

be 0.22 gharial/km, which compares poorly with the density of 2.9 gharial/km. found at present in the Chambal (Sharma and Mathur 1997). Though Son is comparably a more favourable habitat, it may be mentioned that it was totally devoid of adult males until a single adult male reintroduction in 1997. No natural breeding was taking place in this sanctuary whereas a healthy population of gharial are regularly and successfully participating in breeding in the Chambal every year.

References

KHAN. Z (1993) - Son Gharial Sanctuary : Summary Plan & Management. Mimeo. Forest Department, Madhya Pradesh, 16p.

SHARMA. RK, SANJAY SHARMA and R MATHUR (1995) - Wildlife Survey in Madhya Pradesh – II Survey Report on Ken Gharial Sanctuary. *Journal of Freshwater Biology*

SHARMA. RK, SANJAY SHARMA and R MATHUR (1997) - Status and distribution of fauna in Son Gharial Sanctuary, Madhya Pradesh, *The Indian Forester*.

SHARMA R.K. and R.MATHUR (1997) - Biodiversity in National Chambal sanctuary, Status and Strategies for Management. Annual Report to the Madhya Pradesh Council of Science and Technology, Bhopal, mimeo.

Conservation Status of the Gharial in Uttar Pradesh

Ashok Singh
Ram Lakan Singh
and D Basu

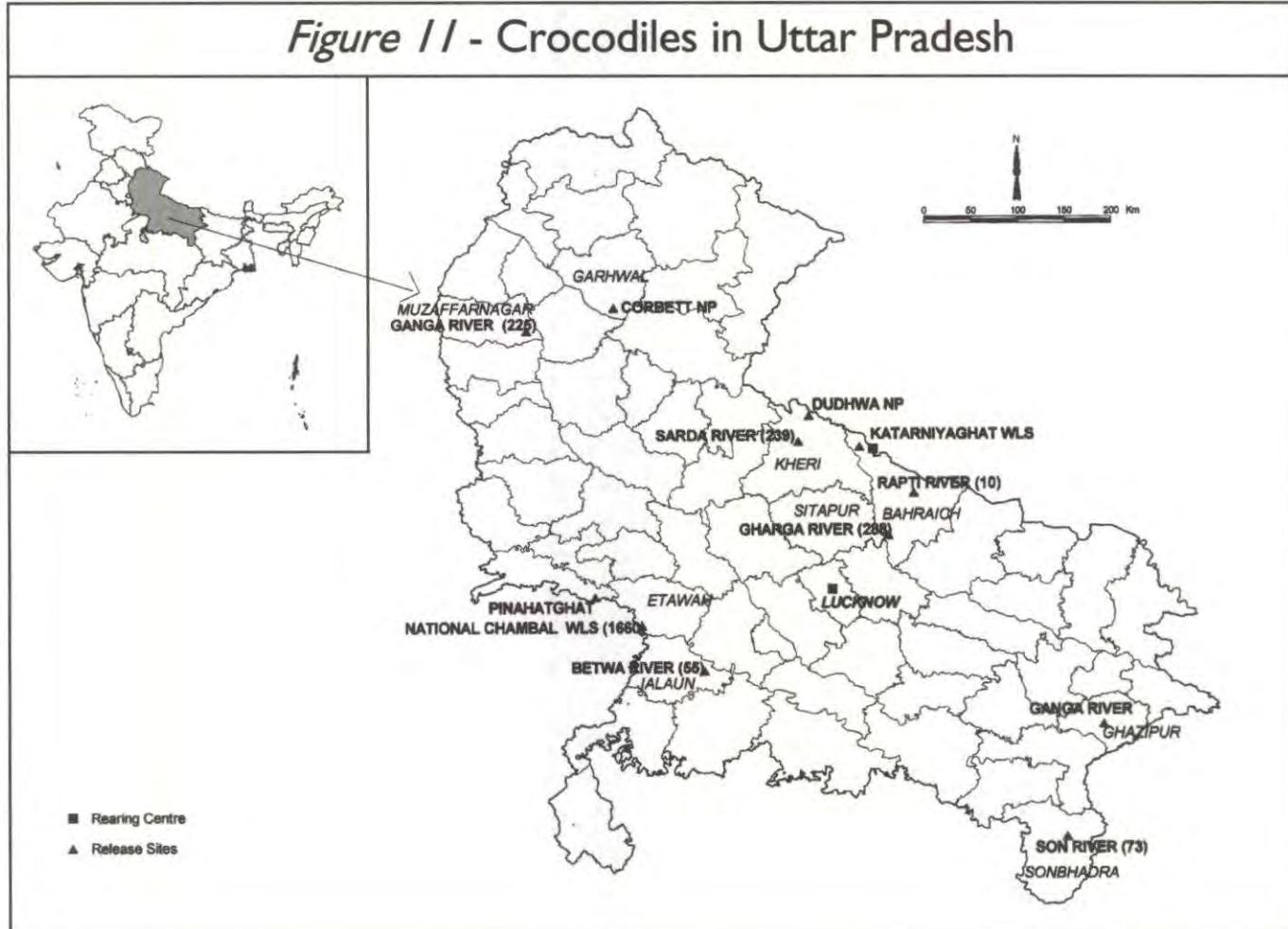
A LARGE PORTION OF THE gharial's distribution lies within the state of Uttar Pradesh, and one of the last surviving breeding populations of the species' was found in the Girwa river in the Distt. Bahraich. With the initiation of Government of India/UNDP/FAO Crocodile Conservation Project, it became necessary for Uttar Pradesh to embark upon a comprehensive management programme for gharial.

Accordingly, a Gharial Rehabilitation Project was started by the Wildlife Preservation Organisation of the UP Forest Department in 1975. This programme has contributed to the rapid improvement in the gharial's status not only in Uttar Pradesh but also in the neighbouring states of Madhya Pradesh and Rajasthan. In fact, the captive-breeding programme for gharial is one of the two such successful wildlife conservation programmes in the country.

The main thrust of the Gharial Rehabilitation Project has been the 'head start programme' comprising collection and incubation of eggs from the wild, rearing of the resultant hatchlings in captivity and supplementation of depleted wild

populations with the captive reared gharial. Two rearing stations, called Gharial Rehabilitation Centres, were established for this head start programme in the state in 1976, at Kukrail Reserved Forest near Lucknow and at Katerniaghata in West Bahraich Forest Division. The two centres together possess facilities to rear up to 800 hatchlings annually and an approximately equal number of juvenile gharial to the prescribed size for supplementation in rivers. Between the years 1975 to 1998, 10,782 eggs of gharial were acquired from the three different sources for the programme viz., Chambal and Girwa rivers and the Gharial Breeding Enclosure at the Kukrail Centre. The contributions of each of the aforementioned sources amounted to 46.5, 36.6 and 16.9 percent of the total.

The most successful and commonly used method for incubation of eggs was to allow 90% of incubation *in situ* in the wild nests, and then collect and transport these to hatcheries at the Rehabilitation Centres, where sand-filled, brick cubics were used to complete the incubation. This method gave an overall mean 75.6% incubation success for gharial eggs in the project (81.5%

Figure 11 - Crocodiles in Uttar Pradesh

in case of eggs collected from the Chambal river). In addition to gharials hatched from eggs, a few neo-nates were also collected in certain years for captive rearing.

At the Gharial Rehabilitation Centres, hatchlings are reared for one year in concrete rearing ponds of size $2 \times 2 \times 3$ m, and thereafter in larger ponds of two sizes – $4 \times 4 \times 1$ m; or $10 \times 6 \times 2$ m. An analysis of the age classes of gharials at the time of their disposal from the Centres shows that about 20% of gharial have been reared up to 2-3 years, 45% for 3-4 years age, 15% for 4-5 years, 3% for 1-2 years and about 4% for 5 years or more. The remaining comprise hatchlings in their first year.

At the Rehabilitation Centres, mortality was confined predominantly to hatchlings, with only rare instances of mortality in animals over one year old. Of gharial hatchlings reared in captivity in UP, 49% survived beyond the age of one year (59.2% in the case of the Kukrail centre). The major reasons for mortality among hatchlings in certain years have been (1) A debilitating liver ailment complicated with infection of unabsorbed yolk; (2) toxicity due to accumulation of undigested fish in the stomach; and (3) a neuro-muscular disorder of unknown etiology. At the Katerniaghata centre, congenital debility and cervical deformities of hatchlings

produced from eggs incubated at sub-optimal temperatures, and hypoglycemic syndrome induced by stress resulting from ineffective protection from extremes of wet, cold water conditions were causes of mass mortality in some years.

However, from the great differences in the observed survival rates of animals reared in captivity, it is evident that hatchlings too have high immunity to disease and survive well if they are congenitally robust and are reared under optimum conditions. The two main factors which have ensured high survival rates of hatchlings are the ample availability of live fish feed and adequate protection from extreme weather conditions.

Gharial hatchlings, 35-38cm at birth, grew annually by 35-40cm of the total body length, till the age of five years. Females reached a total body length of 3.0- 3.5m. in their 11th year, showing an average increase in length of 20-25cm per year between the ages of 5 and 11 years.

The gharial hatched at the Rehabilitation Centres prior to 1994 have mostly been disposed off while those hatched between 1994 and 1998 are still being reared in captivity. Of the 4,331 gharial successfully reared at the centres, to date 3495 have been released into the rivers, while another 184 transferred to zoos or other animal collections.

Captive bred gharials were first released in rivers in 1979, and thereafter more or less on an

annual basis. Approximately 70% of the releases were done in five protected areas, which are under active wildlife management. The rest were experimentally reintroduced into rivers bordering or outside the protected areas, from where the species has been extirpated in the remote or recent past.

At the PHVA workshop on gharial conducted in 1995, the status of gharial populations in different rivers was scrutinized in detail. At the workshop, it was inferred that, in the context of the present knowledge of gharial population biology and provided that assumptions made regarding the composition of meta and sub-populations are correct and the nature of threats to this population do not undergo dramatic changes in the future, the Chambal river population had achieved a satisfactory level of self-sustenance. The Katerniaghata population, on the other hand, faces a grave threat of extinction, probably because of the inadequate rates of recruitment of resident adults into the population to make good the gradual loss of animals due to old age and other reasons.

Collection of wild laid eggs have been discontinued since 1992. Currently, the head start programme of UP Gharial Conservation Project is sustained by eggs laid in captivity in the breeding enclosure for gharial at Kukrail and reserves of breeding animals being reared to replace those lost through disease or old age. Because of the scaling down

of the programme, selected pens are being modified and developed for rearing of other threatened aquatic wildlife. The Kukrial Gharial Rehabilitation Centre attracts over two lakh local and outstation visitors annually and continues to contribute towards raising public awareness towards conservation of the gharial.

Whitaker, R. and daniel, JC. 1980. The status of Indian crocodilians. J.Bombay Natural History Society 75, Supplement : 1283-1245.

IUCN, CBSG India. 1995 Report. Population and Habitat Viability Analysis Workshop for Gharial. Gealior. Eds. R.J.Rao, D.Basu, S.M.Hasan, B.B.Sharma, S.Molur, S.Walker, mimeo.

References

Biswas, S. 19670. A preliminary survey of gharial in the Kosi River. Indian Forester 96 : 705-10.

Singh, V.B. 1978 Status of the gharial in Uttar Pradesh and its rehabilitation. J. Bombay Natural History Society 75 (3) : 668-683

Status and Conservation of Gharial in Nepal

Dr Tirtha M Maskey

THE ADULT MALE GHARIAL develops a large, cartilaginous protuberance on the end of its snout, and, in fact, the name gharial originated from the resemblance of the protuberance to a ghara or earthenware pot common in India and Nepal (Smith 1931). Mystical beliefs have been attributed to the ghara in Nepal. Local tribesmen (specially the Tharu) believed that a ghara placed under the pillow of an expectant women relieved and speeded labor (Mishra and Maskey 1981). They also believed that when the ghara is made into incense and burned in their fields, crops are freed of insects and other pests.

Gharial eggs were believed to have medicinal value in part of Nepal. The local Tharu community believed that gharial eggs are aphrodisiac and medicinal value. For example, the dry powder of the egg is considered to be effective as a cough medicine (Maskey 1989). The local tribesmen also used eggs as the substitute of their meal. As the eggs do not test well, they were mixed with flour and prepared as bread (Maskey 1994).

Geographic Range & Distribution in Nepal

Historically, the gharial was abundant in all the large river systems of the Indian sub-continent. Its range extended throughout the Gangetic plain, west to the Indus River in Pakistan, north and north-east to Nepal and Bhutan, east to Burma, and south to Orissa in India (Neill 1971). The gharial is now restricted to scattered, isolated population in India, Nepal and Bangladesh. It has been reported to be extinct in Burma and Pakistan (Behura and Singh 1978).

Until the early 1960s, gharials were found in all the major river systems of Nepal, including the Mahakali, Karnali, Babai, and Rapti rivers in western Nepal, the Kali Gandaki and Narayani rivers in central Nepal and the Koshi River in eastern Nepal. By the late 1970s, there had been a drastic depletion in their abundance and distribution; in fact, the wild gharial had become extinct in the Mahakali and Rapti rivers in western Nepal and Koshi River in eastern Nepal.

Many factors contributed to the decline of the gharial population:

habitat loss and disturbances, lack of strict enforcement of existing laws, entrapment in nylon gill nets introduced for fishing, construction of reservoirs and barrage in suitable habitat, and poaching of eggs by the local people for medicine and food. Collectively, these factors have resulted in the gharial becoming one of the rarest and most endangered crocodilians in Nepal. The gharial population in Nepal would probably be on the verge of extinction were it not for the present gharial conservation project. Gharials in Nepal are fully protected under the National Parks and Wildlife Conservation Act 1973, and are listed as "endangered species" in the IUCN Red Data Book 1975.

A field study of gharial (*Gavialis gangeticus*) was conducted in the Royal Chitwan National Park and Royal Bardia National park during 1997 to determine the status of gharial in the Kali, Narayani, Karnali and Babai river systems of Nepal. Systematic survey conducted in December reveals that a minimum of 55 wild gharials and 50 released gharials survived in the Narayani, Kali, Karnali and Babai rivers. The sex ratio of wild gharial 1 male to 10 females was at a critical stage. The low number of males was attributed to the heavy poaching of males in the past. The population may be sustained by releasing captive-released gharials.

Study area

The study was conducted in the Karnali and Babai rivers of Royal Bardia National Park and Narayani and Kali rivers of the Royal Chitwan

National Park in central Nepal. The Narayani Nepal's third largest river flows through a relatively low gradient and is fed principally by two major rivers, the Kali and Trisuli, which originate in the Himalayan region. The Narayani River has a maximum width of a kilometer and consists of many channels and islands. It swells to a maximum level during the monsoon of June-September, and carries a high sediment load. During the dry season (December-March) the river recedes to the center of the flood plain, and is fed by snow melt water from the Himalayas. The river is flanked by sandbanks, rocks, and stands of phragmites (*Phragmites karka*) and other grasses.

The Mugu Karnali rivers, originating in Ladakh Himal, joins the Humla Karnali which originates in China (Tibet), giving rise to the Karnali river. The Karnali, which flows for 507 km., is characterized by many gorges. One of the areas that provided habitat for gharials was the Chisapani Gorge, which lies in the Royal Bardia National Park in western Nepal. This habitat was severely degraded by the construction of a bridge over the Chisapani Gorge.

Methods

Surveys of gharial were conducted in the Karnali and Babai rivers of Royal Bardia National Park and the Narayani and Kali rivers of the Royal Chitwan National Park. Surveys were conducted from dugout canoes with the help of the members of the local ethnic

Table 1
Present status of wild and released gharials in Nepal

River	Min. Wild Gharial Sighted	Min. Released Gharial Sighted
Babai	10	15
Kali	8	0
Karnali	7	10
Koshi	0	4
Mahakali	0	0
Narayani	28	21
Rapti (west)	2	0
Total	55	50

culture, the Bote. The main livelihood of the Bote is derived from fishing in the rivers and consequently, they are very familiar with the habits and natural history of the gharial. During the study period, the entire length of the Narayani, Karnali, and Babai rivers within the park area, and Kali River outside the park was surveyed and the estimated size, sex, and location of sighted animals were recorded. The number of gharials in the Koshi River was recorded on the basis of the warden report.

Results

Approximately minimum of 55 wild and about 50 released gharials were extant in Nepal in 1997 whereas it was about 58 wild and 70 released in 1993. The largest single population of wild gharial, consisting of minimum 36 adult was found in the Narayani and Kali rivers. The smallest numbers of minimum of 2 wild gharials were estimated from Rapti (west) river in western Nepal. Similarly among the released gharials, 21 were

recorded from Narayani and 4 from the Koshi River.

In Chitwan Sharma (1977) reported a population of 58 wild gharials in the Kali and Narayani rivers. Minimum population estimates of 53, 60, 57, 56, and 51 wild gharials were calculated from 1980, 1983, 1984, 1986, and 1987 surveys respectively, in the Narayani and Kali rivers (Maskey, 1989).

Hundreds of gharials were observed on the Narayani River prior to the construction of Gandak barrage near the Indo-Nepalese border in 1964. In the early 1950s, about 235 gharials were counted along the river between Narayanghat and Tribeni (Juthe Ram pers. comm.). The gharial had been exterminated by poachers and barrage construction (Jung Prasad pers. comm.). Similarly many gharials and muggers were observed on the upper and lower Karnali River prior to the survey of Karnali dam site in 1970s (Krishna Man pers. comm.), but at present

the population of gharial in the Karnali River is highly uncertain. The local people living near Karnali River reported that earlier in 1960s, they observed as many as 20 gharials in one spot of the Kachali area (Shrestha 1990). He also reported 9 muggers, 11 gharials in the various spot of the Karnali River, whereas 10 gharials were detected in both 1978 and 1979 (Bhim Gurung pers. comm.). A survey conducted in 1987 reported the occurrence of seven adult and two juvenile gharials in the Karnali River, seven in Babai River, and three or less in the Rapti River of western Nepal (Krishna Man pers. comm.). During the field survey in Karnali River, seven adult gharials all females were observed in the upper Karnali River (Chisapani Gorge area), whereas not a single gharial was observed in the lower area.

During the monsoon season, wild gharials enter into the tributaries to avoid the increase force of waterflow in the Narayani River. A maximum of five wild gharials was counted in the Rapti River of Royal Chitwan National Park.

The visually observed sex ratio of the gharial in the Narayani, Karnali and Babai rivers strongly favors females represent a problem. The highest sex ratio of the gharial 1 male to 6 females was recorded in 1984, 1 male to 9 females in 1987 and 1 male to 10 females in 1993 and 1997. The low number of male can be attributed directly to a heavy poaching of the male in the past; temperature effects on incubation/hatching in the natural

condition. In the future releasing more captive reared males will increase the male gharial number, however that strategy does not lessen the severity of the current situation.

Conservation strategy

The survival of the gharial in Nepal is threatened primarily by continuous habitat destruction that is related to increasing human pressure on the environment due to extensive agriculture, firewood collection, cattle grazing, grass cutting and heavy traffic in the river course. Since the gharial population has continued to decline, conservation measures are necessary to protect the surviving population. Fewer than 1% of all gharials hatched in nature reach a length of 2m, a length at which they are generally secure from nature predation (Singh 1978). One breeding female may lay from 14 to 62 eggs in a clutch (Maskey 1989), but the eggs generally fall victim to predators, to poachers and particularly to flooding. To protect this animal from extinction, His Majesty's Government of Nepal strongly supported by the Frankfurt Zoological Society, launched its Gharial Conservation Project in Royal Chitwan National Park in 1978. The objective of the Chitwan rehabilitation project are to protect natural nest sites, to carefully collect and incubate the wild eggs, and to rear hatchlings to a length of 2m for restocking in the major river systems in Nepal. A similar project was initiated in Royal Bardia National Park Headquarter, but later abandoned

because of heavy flooding in the rearing facilities. At present it is renovated and the facilities raised some hatchlings from the Babai River.

Since 1981, the gharial conservation project adopted several strategies. It included released of the captive reared gharials into the major river systems, updating the status of wild and released gharials in Nepal, identifying suitable habitat for reintroduction and protection, collection of wild eggs from the Kali and Narayani rivers. The strategy also included incubation, and rearing at Kasara, reintroduction of captive reared stock, and long term monitoring of the effectiveness of the reintroduction.

References

BEHURA, BK and LAK SINGH (1978) - Conservation of crocodiles in India. *Indian Forester* (Special issue on Inter. Symp. on Tiger): 83 - 92.

GMELIN, JF (1789) - Linne sisteme naturae. Leipzig ed. 13. 1978 (1): 1057

IUCN (1975) - IUCN Red Data Book. Inter. Union. For Conserv. of Nat. and Natural Resour. Morges, Switzerland.

MARTIN, BG and DA BELLAIRS (1977) - The narial excrescence and pterygoid bulla of the gharial, *Gavialis gangeticus* (Crocodilia). *J. Zool.* London, 182: 541-558.

MASKEY, TM (1989) - Movement and survival of captive reared gharial *Gavialis gangeticus* in the Narayani River, Nepal. *Ph.D. Dissertation*, University of Florida, USA.

MASKEY, TM and HF PERCIVAL (1994) - Status and conservation of gharial in Nepal. Paper submitted to *XIIth Working Meeting of Crocodile Specialist Group*. Pattaya, Thailand.

MISHRA, HR and TM MASKEY (1981) - Saving the gharial crocodile. *Die Inter. Zeitschrift fur Tier, Mensch und Nat.* 15 - 18.

NEILL, WT (1971) - The last of the ruling reptiles: alligator, crocodiles, and their Kin. *Columbia Univ. Press*, Ithaca, New York, N. Y. 486 p.

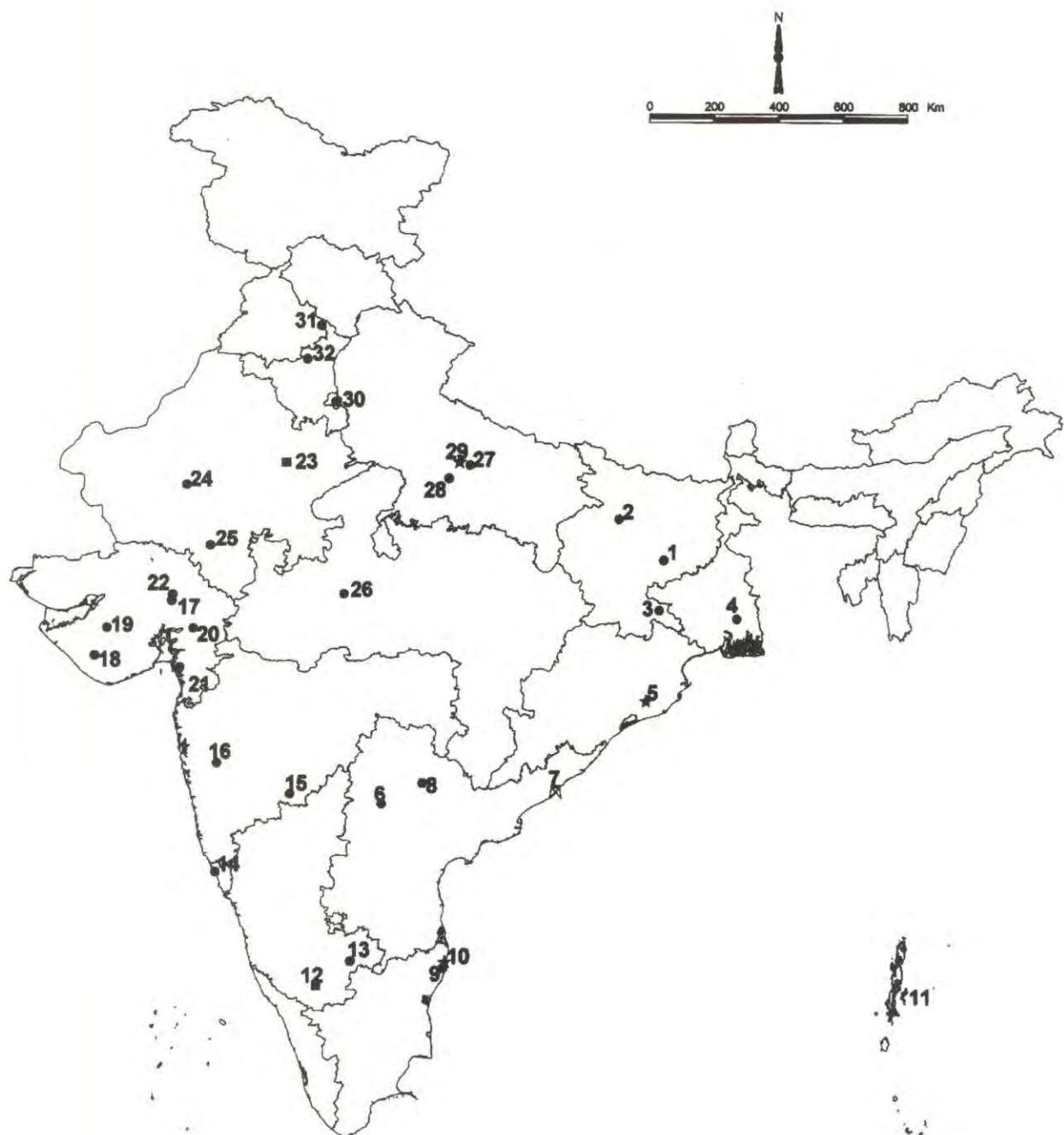
SHARMA, MS (1977) - Report on the survey of gharial in the Narayani River system. *Report submitted to the Department of National Parks and Wildlife Conservation*, Kathmandu, Nepal. 15 p. (mimeo).

SHRESTHA, TK (1990) - Resource ecology of the Himalayan waters: A study of ecology, biology and management strategy of fresh waters. *Curriculum Development Centre*, Tribhuvan University, Kathmandu, Nepal.

SINGH, VB (1978) - Status of the gharial in UP and its rehabilitation. *J. Bombay nat. Hist. Soc.* 75(3):668-683.

SMITH, MA (1931) - The fauna of British India including Ceylon and Burma. *Reptiles and Amphibia*. I. London. Taylor and Francis Ltd, London. 185 p.

Figure 12 - Zoological parks in India breeding Indian crocodilians
(See Box on next page for names)



- Mugger
- ▲ Saltwater Crocodile
- Gharial & Mugger
- ▢ Mugger & Saltwater Crocodile
- ★ Mugger, Gharial & Saltwater Crocodile

Zoological parks in India breeding Indian crocodilians

1. Jawaharlal Nehru Biological Park (Bokaro, Bihar), Mugger	11. Mini Zoo, (Port Blair, Andaman & Nicobar Island), Saltwater Crocodile	22. Indroda Nature Park (Gandhi Nagar, Gujarat), Mugger
2. Sanjay Gandhi Biological Park (Patna, Bihar), Mugger	12. Sri Chamarajendra Zoological Garden (Mysore, Karnataka), Gharial & Mugger	23. Jaipur Zoo (Jaipur, Rajasthan), Gharial & Mugger
3. Tata Steel Zoological Park (Jamshedpur, Bihar) Mugger	13. Banerghatta Zoo (Bangalore, Karnataka), Mugger	24. Jodhpur Zoo (Jodhpur, Rajasthan), Mugger
4. Alipur Zoo (Calcutta, West Bengal), Mugger	14. Bondla Zoo (Panaji, Goa), Mugger	25. Udaipur Zoo (Udaipur, Rajasthan), Mugger
5. Nandankanan Zoological Park (Bhubaneswar, Orissa), Gharial, Mugger & Saltwater Crocodile	15. Mahatma Gandhi Rastriya Udyan (Sholapur, Maharashtra), Mugger	26. Van Vihar National Park (Bhopal, Madhya Pradesh), Mugger
6. Nehru Zoological Park (Hyderabad, Andhra Pradesh), Mugger	16. Pune Snake Park (Pune, Maharashtra), Mugger	27. Prince of Wales Zoological Garden (Lucknow, Uttar Pradesh), Mugger
7. Indira Gandhi Zoological Park (Vishakhapatnam, Andhra Pradesh), Mugger & Saltwater Crocodile	17. Sayaji Baug Zoo (Baroda, Gujarat), Mugger	28. Kanpur Zoological Park (Kanpur, Uttar Pradesh), Mugger
8. Vanvigyan Kendra (Warangal, Andhra Pradesh), Mugger	18. Sakkarbaug Zoo (Junagadh, Gujarat), Mugger	29. Kukrail Gharial Rehabilitation Centre (Lucknow, Uttar Pradesh), Gharial, Mugger & Saltwater Crocodile
9. Arignar Anna Zoological Park (Vandalur, Chennai, Tamil Nadu), Mugger	19. Balbhavan Children's Dreamland (Rajkot, Gujarat), Mugger	30. National Zoological Park (Delhi), Mugger
10. Madras Crocodile Bank (Mammalapuram, Tamil Nadu), Gharial, Mugger & Saltwater Crocodile	20. Kamala Nehru Zoological Gaeden (Ahmedabad, Gujarat), Mugger	31. Mahendra Chaudhury Zoological Park (Chhat Bir, Chandigarh), Mugger
	21. Surat Municipal Zoo (Surat, Gujarat), Mugger	32. Kurukshetra Crocodile Centre (Kurukshetra, Haryana), Mugger

(iii) Social grouping of breeding stock with proper sex ratios.	References
(iv) Good natural diet.	BUSTARD, HR (1980) - Captive breeding of crocodiles. <i>The Care and Breeding of Captive Reptiles</i> . Eds S Townson, NJ Millichamp. DGD Lucas and AJ Millwood. British Herpetological Society.
(v) Proper care of eggs and hatchlings.	INTERNATIONAL ZOO YEAR-BOOK, Vols 1-27.
(vi) Minimising disturbance and vandalism, through education.	
(vii) Some amount of co-ordination.	

Ex-situ Conservation -

2

Role of Nandan Kanan Zoological in the Conservation of Indian Crocodilians

LN Acharjyo

ALL THE THREE SPECIES OF Indian crocodilians (gharial, mugger or marsh crocodile and saltwater or estuarine crocodile) exist naturally in the wild in Orissa. In June 1974, a preliminary survey of crocodilians in the state carried out by FAO/UNDP, however, revealed that all the three species of crocodilians are endangered/depleted in their natural habitats. It was felt that unless the existing handful population of these crocodilians was increased through release of captive bred/reared specimens into the wild, the recovery of the seriously depleted crocodilian population would either be not possible or would be delayed.

Based on the recommendations of the above survey report, an integrated scheme for the conservation of all the three species of crocodilians in Orissa was envisaged and implemented by the wildlife wing of the State Forest Department in 1975-76, with Central funding and technical expertise support from FAO/UNDP consultant Dr HR Bustard. It was further envisaged, as a part of this scheme, to have an ex-situ captive breeding programme of all these three species, in addition to

the *in situ* conservation measures to be taken up in the state.

The Nandan Kanan Zoological Park (NKZP), established on 29 December 1960 had the experience and expertise in the maintenance of gharial, mugger and saltwater crocodiles in captivity since 1963, 1964 and 1967 respectively. The geographical situation of the park within the natural distributional range of these three species alongwith its existing facilities and advantages, e.g. space, skill and expertise, maintenance staff component for the scheme, veterinary care, etc. helped NKZP to be identified as an ideal location for starting captive breeding of all the three species of crocodilians. This was in conformity with the objectives of the World Zoo Conservation Strategy/ National Zoo Policy and IUCN Captive Breeding Policy which strongly advocate the integration of zoo conservation efforts with other conservation measures.

Accordingly, a separate and spacious crocodile breeding complex with three nature simulating breeding enclosures was created within NKZP. These

were so located as to have minimum disturbance and maximum privacy for crocodilians. Besides, an additional artificial hatchery, hatching/yearling pools and an office-cum-laboratory facility was also created.

Captive breeding and rehabilitation of species

NKZP was successful in breeding all the three species of crocodilians during the years 1980 - 1985. The zoo hatched crocodilians were reared in hatching/yearling pools of the park to over 1m body length and then released into identified natural habitats/protected areas under a rehabilitation programme or supplied to different zoo in the country and abroad.

Presented below are the initiatives and activities of NKZP with regard to the three crocodilian species separately.

Gharial

A large oval-shaped concrete pool with a capacity to hold 2.7 million litres of water was constructed inside the gharial breeding enclosure (area 71 x 51m). The pool measured 60m at the longest part, 30m at the widest part and had a depth of 9.15m at its deepest. The area was fenced with 2m high wall all round except 30m on the viewers' side where a dry moat and a parapet 0.5m high was provided. Provision was made to replace about 0.45 million litres of stagnant water with fresh water daily from the nearby lake for some time of the day. A large sand bank with suitable riverine vegetation, covering an area of

60m x 7m and 2.4m high was created on one side of the enclosure for crocodiles to bask and for egg-laying, which mimicked the natural gharial habitat of the Satkoshia Gorge of river Mahanadi, the ideal natural habitat of the gharial (Mohapatra et.al., 1976; Bustard and Moharana, 1985; Acharjyo et.al., 1996a).

One male (2.7m) aged about 16 years and two females (2.50m and 2.65m) aged about 12-13 years were introduced into the breeding pool on 13 February 1976 (Mohapatra et.al.; 1976; Bustard and Moharana, 1985). Subsequently, four more sub-adult female gharial measuring 1.5-1.8m (three) and 2.3m (one from Thiruvanthapuram zoo) were added to this pool during 1979. Another adult male (3.7m) obtained as a breeding loan from Frankfurt Zoological Society, Germany was introduced, increasing the breeding population to eight (2 males and 6 females). The resident male was unfortunately killed by the Frankfurt male during the breeding season in February 1980 (Acharjyo et.al., 1996b).

The successful breeding in captivity of gharial was recorded for the first time at NKZP in 1980. Since then, the gharial breeding involving 1-5 out of 6 females and one male gharial has been an annual feature in the park..

Over a 15 year period from 1980 to 1994, 1832 eggs were laid in 57 clutches, the size of which varied from 2-57 eggs with a mean of

32.14. Out of these eggs laid, 1235 hatched, giving a hatching percentage of 67.41. The eggs were always laid in March and hatched in May or early June. All six adult females were in the egg-laying stage but the number of females that laid eggs during each breeding season varied from 1 to 5, suggesting that one male might not be able to mate with more than five females in a breeding season.

The first batch of 35 zoo bred gharial were reintroduced into the river Mahanadi of Satkoshia Gorge Sanctuary on 24 October 1986. So far, 493 gharial yearlings have already been released at different locations in river Mahanadi in the Satkoshia Gorge Sanctuary.

Besides, 78 zoo bred juvenile specimens have been supplied to different zoos in Itanagar (Arunachal Pradesh), Sepahijala (Tripura), Bokaro (Bihar), Bhilai in Jamshedpur, Madras Crocodile Bank, Vandalur and Chennai Snake Park, (Tamil Nadu), Vadodara and Junagadh (Gujarat), Mumbai, Pune, Mysore (Karnataka), Thiruvananthapuram and Thrissur (Kerala) and also Singapore.

Mugger crocodile

The mugger breeding enclosure, constructed in 1978-79, has a spacious pool measuring 38m at the longest part and 17m at the widest part with a depth of 2m, having a capacity to hold 8,26,000 litres of water. The land area surrounding the pool is about 1250sq.m with suitable vegetation. A compound wall 2.1m high was

erected all round except 23m on the viewers' side which had a dry moat and 0.6m high parapet. There is provision of replacing stagnant water with fresh water at frequent intervals (Acharjyo et.al., 1996c).

Five adult mugger (2 males and 3 females) procured from Tamil Nadu were released into this pool in January 1979. Subsequently, four more (2 males and 2 females) of Tamil Nadu origin were added to this pool in October 1980. Two of these (one male and one female) died in October 1980 and January 1981.

Between 1981 and 1992, egg-laying took place every year except in 1986, 1987 and 1988. The number of females involved in egg-laying varied from one to three. The number of eggs laid in each of 14 clutches recorded during the other years varied from 4-30 with a mean of 20.7. In all, 290 eggs were laid. The eggs were invariably laid in March but the eggs hatched from mid-May to early June. The hatching has not been satisfactory. The 72 eggs laid in 4 clutches in 1981 (1), 1985 (2) and 1990 (1) did not hatch at all. Of the remaining 218 eggs laid during the other years, 82 hatched, giving hatching percentage of merely 37.6.

So far, 51 juvenile park-bred mugger have been released into the hill streams of Simlipal Wildlife Sanctuary (12), river Mahanadi in Satkoshia Gorge Sanctuary (35) and the remaining four juveniles into two waterbodies inside Chandaka-Dampara Wildlife

Sanctuary (Kar et.al., 1998). Other than these, seven mugger have been supplied to zoos at Sepahijala, Tripura (2); Bokaro Steel City, Bihar (4) and Kapilash, Orissa (1).

Saltwater crocodile

A saltwater crocodile breeding enclosure with a spacious pool of almost the same size and capacity as the mugger breeding enclosure was constructed in 1978.

A lone female of this species in the park since November 1967, has been laying infertile eggs since 1975. Between 1975 and 1984, it laid a total of 221 eggs in seven clutches, with no record of egg laying in 1979, 1981 and 1983. The eggs were laid during the three-month period, April-June and the clutch size varied from 22 to 35, with a mean of 31.6 eggs. But all these eggs were infertile.

This female was paired with an adult male of the same species procured from Crocodile Rehabilitation Centre, Kukrail (Uttar Pradesh) in April 1983 (Acharjyo and Patnaik, 1987). However, successful breeding of this pair was recorded for only two years - 1985 and 1986, as the female died on 13 April 1987. The two clutches of fertile eggs laid on 15 April 1985 and 18 April 1986 had 16 and 21 eggs respectively. The incubation period recorded varied from 74 to 83 days, 11 (in 1985) and 9 eggs (in 1986) hatched between 30 June and 6 July. The percentages of hatching were 68.75 (1985) and 42.86 (1986).

However, no reintroduction programme or supply to other zoos could not be carried out since the number of captive bred specimens was insufficient.

Research

One of the objectives of the scheme as well as that of any modern zoological park is to acquire extensive scientific knowledge through scientific research in captivity to help in ex-situ and in-situ conservation. At NKZP, data on management, different aspects of breeding biology, growth, behaviour, health care, etc. were generated through keen day to day observation and documentation. The data so collected is likely to help in improving the existing management practices of these three species both in captivity and in the wild. So far 20 notes/articles based on the observations made at NKZP on the different aspects of these three species have already been published in leading journals of the country and abroad.

Conservation awareness

No conservation programme can ever be successful without public support, and this is only possible through education and awareness among the public. The NKZP has been attracting annually 10 to 12 lakh visitors, both Indians and foreigners, of all ages, sexes, religion, rich and poor, urban and rural speaking different languages.

The crocodile complex with a number of living specimens of different age groups of all three species of crocodilians, along with

centres have yielded the desired results, and up till now, about 1000 crocodiles, bred and reared in these centres, have been released in different waterbodies in the state.

The eggs procured from the Hiran dam within the Gir Sanctuary were hatched artificially in the Sasan Gir rearing centre. Over the period, 308 crocodiles have been distributed to various zoos and other such centres for captive breeding and rearing. 25 crocodiles were given to Fatehsing Rao Zoo Trust, Baroda in 1978, 190 to the Natural History Museum, Gandhinagar in 1978 & 1980 and 1993 to Sakkarbag zoo, Junagarh during 1980 to 1986. The relocation of crocodiles commenced on 15 May 1984. A total 1013 crocodiles were released in nature as a part of this programme. Of these, 973 were released in the Gir sanctuary, 13 in Ranjit Sagar lake, 14 in Narmada dam, 4 in Karjan dam and 8 released in Ajwa dam.

In Gir Wildlife Sanctuary alone, as part of the reintroduction programme, 148 crocodiles were released in Kamleshwar dam, 200 in Rawal dam, 264 in Singoeda dam, 94 in Machchhundri dam, 40 in Billiard Kankai, 25 in other small waterbodies and 2 were released in Jarardi river.

Also as a part of reintroduction and augmentation of crocodile populations in nature, 145 crocodile eggs were given to Andhra Pradesh, 50 crocodiles and 51 eggs to Maharashtra and 30 crocodiles to Diu.

Rearing centre, Gandhinagar

Located in the outskirts of the Gandhinagar city, and covered with dense man-made forest on the picturesque bank of the river Sabarmati, Indroda Nature Park is an ideal place to have a such breeding programme of crocodile. The breeding programme here was initiated in 1979, which is managed by the Gujarat Ecological Education and Research (GEER) Foundation, Gandhinagar, which was known as Natural History Museum prior to 1984. 190 crocodiles were moved to this centre for captive breeding and this centre has successfully bred and released in the Rawal dam in the Gir Wildlife Sanctuary. Similarly, in September 1997, 25 crocodiles were released in Machchhundri dam of in the wildlife sanctuary.

The breeding of crocodiles in Gujarat has yielded positive results, which is confirmed by the increase in the population of crocodile in the state. The crocodile-rearing centre at Sasan Gir have been very successful in its objectives and have restocked the crocodiles in Gir Sanctuary and National park. The population increase in the waterbodies of Junagarh district, which is reflected from above figures, is due to this rearing centre.

FUTURE PERSPECTIVE - I

Sustainable Use of India's Crocodile Resource

Rom Whitaker

THE CROCODILE IS PERHAPS an unlovely animal, but the demand for its skin has never diminished since the first shoes and bags became popular well before the turn of the century. The usage of crocodile skins peaked at an estimated 5 million per year in the 1950's. Though the demand remains the same, human pressure on crocodiles have slashed the trade to under a million skins per year during the 1970's.

The drastic decline in crocodile populations in many countries has caused concern and activated several governments and agencies to initiate conservation measures. The World Conservation Unit (IUCN) has a Crocodile Specialist Group to watch over the interests of the world's crocodiles. The Convention on International Trade in Endangered Species (CITES) ratified by over 145 countries (including India), helps to control trade in those species which are under severe pressure from over-hunting and loss of habitat.

Crocodile conservation becomes necessary because, aside from the obvious value of the skin, meat and other by-products, the crocodile

plays a vital ecological role as master predator in the aquatic habitats where it lives. By preying on weak and diseased fish and animals, it maintains genetic quality; by its habit of selective feeding, it controls predatory fish; its presence thus actually helping to increase yields of edible fish for man.

While many developing countries have found to their dismay that crocodile populations are remarkably easy to exterminate, crocodiles have responded well to protective management initiative, wherever adopted. Crocodile (and alligator) ranching, farming and rehabilitation programmes have been underway in several countries for a number of years. Most of these have been successful in maintaining wild crocodile populations and protecting millions of acres of wetland habitat.

The programmes vary from country to country in dramatically different scenarios, from outright licensed hunting of adult alligators (as in Louisiana), to closed cycle captive breeding (South Africa) and collection of eggs in the wild (Australia and Zimbabwe). Two

things are common to all of these wildlife management operations (a) local people (often tribal people) are making a good economic return, and (b) wild crocodile populations are doing well.

The Indian experience in crocodile conservation and rehabilitation in the last 25 years has been very encouraging. But as a result of persisting with a simplistic policy of bans and attempts to preserve wildlife for its own sake, have drastically dwinded the crocodile populations. Here, conservation is anti-people and the alarming decline in all our major wildlife species is the tragic result. No single conservation strategy can solve the problems faced by wildlife in India and it is vital that we continue to test new and innovative conservation methods - even if it means upsetting some people. Most opponents of sustainable use of wildlife are more interested in protecting the principle of "preservation" rather than trying to solve our problems of dwindling wildlife. Fundamentalist belief in the animal welfare movement and lethargy on the part of some key Government bureaucrats are two reasons why conservation cannot achieve in India what so many other countries have accomplished.

In many countries, conservation through sustainable use is a strategy that has proved remarkably effective in saving wildlife and involving the people in it. It is essential that India too looks

at all the various conservation options, including sustainable use of wildlife if we are to effectively conserve crocodiles and their dwindling habitat. Crocodile farming has done wonders for the crocodilians in many developing countries and India is lagging way behind. It is hoped that the following article will provoke some pragmatic dialogue on this subject so vital to the future of India's crocodilians.

Today, ranching is rapidly becoming the accepted technology for using this valuable natural resource. "Ranching" differs from "farming" to the extent that while the latter infers the actual breeding of adult crocodile in captivity, the former refers to the enrolled utilization of the wild population through collection of eggs and/or young and rearing them to culling size in captivity. Farming demands a sophisticated technology and investment for large enclosures and pond areas, ranching can be done on a small scale with simpler inputs. Where adequate crocodile habitat still exists, the controlled use of the crocodile resource is of reciprocal benefit to the conservation of wild habitat, which is invariably under pressure for many human needs. A simplified demonstration of the value of the wild resource may be outlined as follows.

A female crocodile produces about 30 eggs per year. If, on a conservative estimate, 50% (or 15) of the offsprings from one year are reared to culling size (3 or 4

years in captivity), these 15 crocodiles will have a gross value of Rs 156,000. It can be reasoned then, assuming a female crocodile remains productive for about 30 years, that it is worth an accrued value of Rs. 4,680,000 to protect that single female crocodile and the habitat she lives in.

Utilization models

During several years of serving as a consultant on crocodile farming for the Food and Agriculture Organization of the United Nations, the author had the privilege of experiencing crocodile utilization programmes in Papua New Guinea, Indonesia, Mozambique, Zimbabwe, Australia and the United States.

The Zimbabwe model of ranching is of special interest and has over two decades of background to recommend it. The vital component of monitoring and protecting the wild population of the Nile crocodile in Lake Kariba and on the Zambezi river is the responsibility of the National Parks and Wildlife Department. Five private crocodile ranches are licensed to collect a specified number of eggs on payment of a royalty. In addition, the ranches are obliged to supply 5% of their stock for any restocking scheme deemed necessary by the Government to maintain or boost the wild population.

Mortality of eggs and young crocodiles in the wild is often as high as 95% because of the many predators plus the hazards of flooding. Egg collection and

captive rearing can obtain an 80% survival rate of young crocodiles, and provide the seed stock for ranching operations as well as for rehabilitating depleted wild populations.

Organizations and conventions like IUCN and CITES allow Papua New Guinea, with its network of 200 village and commercial ranches, to export its annual production of nearly a million dollars worth of saltwater crocodile skins, a species endangered almost everywhere else but well looked after in that country.

In the southern USA, the wild population of over 2 million alligators is carefully managed and millions of acres of prime wetland habitat (with the countless organisms therein) protected for the sake of this single resource animal.

France and Japan now top the import market for crocodile skins, paying nearly US \$ 5 per cm of belly skin, measured across the "chest" of the reptile. The skins are converted into glossy, beautiful, strong leather and made into a variety of articles from belts and wallets to handbags and shoes. The preferred size of skin for the tanners is 37-50 cm belly width which is reached in 3 or 4 years when the crocodile is 1.5m long.

It's a long way from the swamps of Papua New Guinea and the mysterious rivers of Africa to the fashionable shops of Tokyo and Paris. But, odd as it seems, the

scaly giants of the rivers can provide employment for tribal people in one part of the world, satisfy the whims of fashion in another and still be safely managed and protected from over-exploitation.

Crocodile resource in India

An accurate census of India's three crocodilian species is not available. The number of gharial in the Chambal river is estimated to be over 1500, and the number of saltwater crocodiles in Bihar Kanika (Orissa) is about 600. These are two carefully monitored crocodilian preserves but most of the others are not. The third Indian species, the mugger, is found in most states in small numbers ranging from 20-200 over a much wider range than the other two. Significant populations of mugger (nowhere a single population of over 200) are still found in Tamil Nadu, Goa, Gujarat, Rajasthan and Andhra Pradesh. Gharial are concentrated in Madhya Pradesh, Uttar Pradesh and Rajasthan and the "salties" are also found in the Sunderbans and the Andaman and Nicobar islands.

Extrapolating from the recent literature on the subject (ART, 1993), it is estimated that the wild crocodile resource in India consists of:

Mugger	5000+
Salt water crocodile	1000+
Gharial	1500- 2000

The three species have been bred in some numbers to restock wild habitats and to partly fulfill the

objectives of the FAO/UNDP sponsored Crocodile Conservation Project. Unfortunately, the project fizzled out and no effort was made to implement the final phase crocodile utilization as a conservation tool. Few adequate habitats have been identified for any further releases and thousands of crocodiles remain "stranded" at over a dozen Government run farms and at least one private one (with 3000 mugger). The estimated captive population of the three species is:

Mugger	5000
Saltwater crocodile	650
Gharial	500

The ideal farm animal

Of the three Indian species, the mugger has proved to be the easiest to breed and maintain. Social by nature, large groups can be kept in captivity with excellent survival and growth rates. A female mugger will lay an average of 30 eggs per clutch, and under the right conditions can lay two clutches per year. She is mature in her sixth year and will go on laying for at least thirty years.

Well-fed mugger can grow from hatchling size (30cm total length) to 150cm in 3 years. At that size, a mugger is worth over Rs. 10,000 for its skin, meat and by-products. The raw skin sells for Rs.200 per cm of belly width and the meat and other by-products are worth about 30% of the total skin value.

In the Indian context, it is logical to start sustainable usage with the

species we know most about. The mugger is a proven success in captivity and the resource base is strong enough to make a start. The other two Indian species are potential resources and indeed the saltwater crocodile skin harvest in Papua New Guinea and Australia produce the world's most valuable skins. Since "salties" have the unpopular habit of taking livestock and occasionally even people, there is all the more reason to give them an economic basis for survival. People who live around crocodile habitat have little time or inclination to appreciate the finer points of crocodiles. To most fishermen around Bhitarkanika or along the Chambal river crocodiles and gharial are predator/competitor - no more and no less. Involving these people in the profitability of crocodilians is an essential step in assuring the long-term survival of these last major crocodile populations. Ranching crocodiles has good potential.

Ranching and farming

Since ranching means "harvesting" a certain percentage of the eggs and young from the wild to hatch and rear them on crocodile "ranches", the wild crocodile and their habitat must be rigorously protected. Research and monitoring are essential components of a ranching programme. However, if the built resource base is not strong enough (as in most parts of India), farming may be the better option. Closed cycle captive breeding of crocodiles, originally taken from wild collected eggs, is the kind of farming that has been a great

success in many countries including Papua New Guinea, Australia and Indonesia. Ideally, the crocodile management programme in India will eventually have both the farming and ranching components.

Crocodile farm economics

There are many levels of crocodile farming. A village level single enclosure farm with one male and two females can be simply run by a family which can either sell the eggs and offspring or grow them to culling size if time, space and resources permit. A large farm consists of about 200 breeding females and 20 males. The egg production would be about 6000 per year and the survival rate can be computed at a conservative 50%, or 3000 young crocodiles.

At three years, the young mugger will reach 1.5m in length and have a skin value of about Rs. 8000. Meat and other by-products can bring the value of each crocodile to about Rs. 10,000. Thus the 3000 surviving crocodiles raised for 3 years have a gross value of Rs. 30 million.

To determine just how profitable crocodile farming in India can be, let us work out the capital and recurring costs for a three year period:

(a) Capital investment

Land (3 acres)	150,000
Purchase of adult crocodiles (220 & Rs. 10,000)	22,00,000

Bibliography

Compiled by
LAK Singh and DP Rath

ABDULALI, H. (1954) - The record of Indian crocodile. *J. Bombay nat. Hist. Soc.* 52(1): 213.

ABDULALI, H. (1938) - The food of the mugger (*Crocodylus palustris*). *J. Bombay nat. Hist. Soc.* 40: 336.

ABDULALI, H. (1957) - Reflected glow from the eyes of the gharial (*Gavialis gangeticus* Gmelin). *J. Bombay nat. Hist. Soc.* 53(3): 769-70.

ABERCROMBY, A.F. (1922) - Crocodile (*Crocodylus palustris*) burying the food. *J. Bombay nat. Hist. Soc.* 28(2): 533.

ACHARYO, L.N., S. BISWAS and R. MISRA (1975) - Some notes on gharial [*Gavialis gangeticus* (Gmelin)] in captivity. *J. Bombay nat. Hist. Soc.* 72(2): 558-560.

ACHARYO, L.N. and R. MISRA (1976) - Egg laying of the mugger (*Crocodylus palustris*) in captivity. *J. Bombay nat. Hist. Soc.* 73(1): 223.

ACHARYO, L.N. and S. MOHAPATRA (1978) - Return of the captive marsh crocodile (*Crocodylus palustris*) into the wild. *Indian forester.* 104(5): 385.

ACHARYO, L.N. and CH.G. MISHRA (1981) - Egg laying and nest-guarding behaviour of estuarine crocodile (*Crocodylus porosus* Schneider) in captivity. *J. Bombay nat. Hist. Soc.* 78(2): 387-390.

ACHARYO, L.N. and S.K. PATNAIK (1987) - A note on the breeding of estuarine crocodile (*Crocodylus porosus*, Schneider) at Nandankanan biological park, Orissa. *J. Bombay Nat. Hist. Soc.* 84(2): 448-449.

ACHARYO, L.N. and S.K. PATNAIK (1989) - Role of Nandankanan biological park, Orissa in rehabilitation of some species of wildlife. *Zoos' print.* 4(12): 4.

ACHARYO, L.N. and L.A.K. SINGH (1989) - Twinning abnormality in *Gavialis gangeticus* (Reptilia, Crocodilia). *J. Bombay Nat. Hist. Soc.* 86(2): 248-250.

ACHARYO, L.N., L.A.K. SINGH and S.K. PATNAIK (1990) - Age at sexual maturity of gharial (*Gavialis gangeticus*) (Reptilia: Crocodilia). *J. Bombay nat. His. Soc.* 87(2): 458-459.

ACHARYO, L.N., L.A.K. SINGH and S.K. PATNAIK (1991) - Occurrence of congenital blindness in Gharial (*Gavialis gangeticus*) (Reptilia : Crocodilia). *J. Bombay nat. His. Soc.* 88(1): 117-118.

ACHARYO, L.N., S.K. KAR and S.K. PATNAIK (1996) - Role of Nandankanan biological park, Orissa, in conservation of the gharial (*Gavialis gangeticus*). *Tiger Paper.* 23(3): 5-8.

ACHARYO, L.N., S.K. KAR and S.K. PATNAIK (1996) - Observations on breeding of mugger (*Crocodilus palustris*) at the Nandankanan zoological park, Orissa. *Cobra.* 26: 18-25.

ACHARJYO, L.N., S.K. KAR and S.K. PATNAIK (1996) - Studies on captive breeding of the Gharial, *Gavialis gangeticus* (Gmelin) in Orissa. *J. Bombay nat. His. Soc.* 93(2): 210-213.

ACHARJYO, L.N. and S.K. DUTTA (1997) - Bent Neck in gharial hatchlings. *Herpetile.* 1(2): 5-6.

ACHARJYO, L.N. (1998) - Role of zoos in the conservation of reptile in India. *Cobra.* 33: 15-22.

ACHARYA, TAPAS (1985) - Captive breeding at Bhagabatpur crocodile farm, Sundarbans (West Bengal), India: the case of a wild caught female (*Crocodylus porosus* Schneider). *J. Bombay Nat. Hist. Soc.* 82(2): 417-420.

ADAMS, A.L. (1867) - Wanderings of a naturalist in India. *Edmonton and Douglas: Edinburgh.*

AGGARWAL, R.K., K.C. MAJUMDAR, J.W. LANG and L. SINGH (1994) - Generic affinities among crocodilians as revealed by DNA fingerprinting with a Bkm-derived probe. *Proc. Natl. Acad. Sci. USA.* 91: 10601-10605.

AGGARWAL, R.K., J.W. LANG and L. SINGH (1992) - Isolation of high-molecular-weight DNA from small samples of blood having nucleated erythrocytes, collected, transported, and stored at room temperature. *GATA (Genetic Analysis, Techniques and Applications).* 9(2): 54-57.

AHMAD, ASHIQ (1986) - The distribution and population of crocodiles in the provinces of Sind and Baluchistan (Pakistan). *J. Bombay Nat. Hist. Soc.* 83(1): 220-223.

AHMED, Q.Q. (1945) - Syncope on a crocodile. *J. Bombay nat. Hist. Soc.* 45: 429.

ALCALA, A.C. and M.T.S. DY-LIACCO (1989) - Habitats. pp. 136-155. In: Ross, C.A. and Garnett, S. (Eds.). *Crocodiles and Alligators. Facts On File, Inc.*, New York.

ALDERTON, DAVID (1991) - Crocodiles and alligators of the world. *Facts on File, Inc.*, 190p. Available at \$24.95 (cloth) from *Facts on File, Inc.*, 460 Park Ave. S., New York, NY 10016-7382.

ALDERTON, DAVID (1991) - *Crocodiles and Alligators of the World / David Alderton, photography by Bruce Tanner.* London: Blanford, 190p.

ALLEN, KENNETH (1978) - What Animal is that / Kenneth Allen. London: Octopus Books, 96p.

ANDERSON, I. (1993) - Rogue crocodile bites hole in lead study. *New Scientist.* 138: 8.

ANDERSON, A. (1875) - Letter excerpt, an account of the eggs and young of *G. gangeticus*. *Journal of Zoology, Zoological Society of London.* X: 2.

ANDREWS, H. (1989) - *Gavialis gangeticus* nest at the Madras Crocodile Bank. *Hamadryad.* 14(1): 13-14.

ANDREWS, H.V. and R. WHITAKER (1989) - Herp Help: A note on gharial oviduct extrusion while nesting at the Madras Crocodile Bank. (Reprinted from *Hamdryad.* 13/2/12/88). *Zoos' Print.* 4(12): 22.

ANDREWS, H.V. and R. WHITAKER (1994) - Status of the saltwater crocodile (*Crocodylus porosus* Schneider, 1801) in north Andaman Island. *Hamadryad.* 19: 79-92.

ANDREWS, H., D.R. BROOKS and H. COOPER-PRESTON (1989) - Symposium: Biology of the Crocodilia. *American Zoologist.* 29(3): 821-?.

ANNANDALE, N (1912) - Zoological expedition to the Abore Expedition II. Reptilia. *Rec. Indian Museum VIII* pp 38. P.38

ANNANDALE, N. (1915) - Fauna of the Chilka Lake. Reptiles and Batrachia. *Mem. Ind. Mus..* P.167-174

ANON (1935) - A large mugger (*Crocodylus palustris*, Lesson) from Bikaner-correction. *J. Bombay nat. Hist. Soc.* 37(2): 493-494.

ANON (1964) - No crocodile from India. *Oryx.* 9: 184.

ANON (1969) - Biology of The Reptilia : Morphology A / edited by Carl Gans, Angus d'A. Bellairs and Thomas S. Parsons. London: Academic Press. xv: 373p.

ANON (1970) - Biology of The Reptilia : Morphology B / edited by Carl Gans and Thomas S. Parsons. London: Academic Press. xiii, 374p., Volume 2.

ANON (1973) - An endangered *Gavialis gangeticus* (Gemlin). *Cheetal.* 16(3): 51.

ANON (1973) - Biology of The Reptilia : Morphology D / edited by Carl Gans and Thomas S. Parsons. London: Academic Press. xii, 539p., Volume 4.

ANON (1974) - FAO India : A Preliminary Survey of the Prospects for Crocodile Farming / Food and Agriculture Organization.— Rome: Food and Agriculture Organization, 1974. 50p. (FO: IND/71/033).

ANON (1974) - General System of Symmetrical Locomotion of terrestrial Vertebrates and Some features of movement of lower tetrapodes / Sukhanov.— New Delhi: Amerind Pub. Co. Pvt Ltd., 274.

ANON (1974) - Survey of *Gavialis gangeticus*. *IUCN Bull.* 5(8): 32.

ANON (1975) - Captive gharial breeding. *Oryx.* 13(2): 184.

ANON (1975) - Fourth gharial sanctuary in India. *Newsl. Madras snakepark trust.* 1(2): 11.

ANON (1975) - Crocodile conservation in India. *Tigerpaper.* 2(4): 16-17.

ANON (1976) - Karnali River. *Newsl. Madras Snake Park.* 1: 7.

ANON (1976) - Breeding of mugger at the Madras snake park. *Newsl. Madras Snake Park and Crocodile Bank.* 1(2): 1.

ANON (1976) - Mugger on a hill. *Newsl. Madras Snake Park.* 1: 5.

ANON (1976) - Orissa crocodile and sea turtle breeding scheme. *Newsletter of the Madras Snake Park.* 1(1): 9-10.

ANON (1976) - Nesting mugger observed. *Newsl. Madras Snake Park.* 1: 4-5.

ANON (1976) - Mugger in drought. *Newsl. Madras Snake Park.* 1: 5.

ANON (1976) - Mugger (*Crocodylus palustris*) hatching ata for 1976. *Newsl. Madras Snake Park and Crocodile Bank.* 1(2): 6.

ANON (1976) - World gharial population. *News. Madras Snake Park.* 1(2): 12

ANON (1977) - Un crocodile geant de 100 millions d'annees. [A giant crocodile 100 million years old.] [in French]. *Miner. Fossiles, Guide Collect.* 32: 34-35.

ANON (1977) - Crocodile breeding - saving an endangered Indian species. United nations press release dated New Delhi 11th Aug. 1977. P. 1-4.

ANON (1980) - Assistance to The Crocodile Skin Industry : Monitoring Workplan. 37p.

ANON (1980) - Crocodile rehabilitation in uttar pradesh. *Brouchure* published by forest department Uttar Pradesh (revised version, 1980). 1980.

ANON (1981) - Assistance to the Crocodile skin industry. *Wildlife Division, Department of land and environment, FAO of the United Nations, Posat Moresby, Jan.* 1981.

ANON (1981) - Telemetric studies on *Gavialis. Hamadryad.* 6(2): 5.

ANON (1981) - *Gavialis: Bangladesh. Hamadryad.* 6(3): 11.

ANON (1981) - News from the Madras Snake Park and Madras Crocodile Bank. *Hamadryad.* 6(2): 1.

ANON (1981) - First successful breeding of ganges gharial (*Gavialis gangeticus*). *Tigerpaper.* 8(1): 10.

ANON (1981) - Madras crocodile bank mugger nesting data for 1981. *Hamadryad.* 6: 11.

ANON (1981) - International Trade in Endangered Species of Wild Fauna and Flora Identification Manual Volume 5 : Parts and Derivatives II: Convention on International Trade in Endangered Species of Wild Fauna and Flora / International Trade in Endangered Species of Wild Fauna and Flora.— Switzerland: IUCN, 1981. *Misc. Vol.IV.*

ANON (1982) - Attack by a nest-guarding female mugger (*Crocodylus palustris*). *Hamadryad.* 7(2): 3.

ANON (1982) - Biology of The Reptilia : Physiology C: Physiological Ecology / edited by Carl Gans and F. Harvey Pough. London: Academic Press, xv, 536p.

ANON (1982) - Saltwater crocodile in south india - first record for forty years. P.

ANON (1982) - When man parasitises crocodiles. *Oryx.* 16(3): 220.

ANON (1982) - Indian Crocodiles Conservation and Research : Proceedings of the First Indian Crocodile Researchers Symposium Katerniyaghat, Uttar Pradesh India 21-25 January 1979 / edited and compiled by L.A.K. Singh and B.C. Choudhury.— India: Forum of Crocodile Researchers, 1982. xv,48p.

ANON (1983) - FAO Crocodile Breeding and management - India : project findings and recommendations., 1983. P. 24.

ANON (1983) - Crocodiles as a Resource for the Tropics. Washington: National Academy Press, 1983. 59p. (Managing tropical animal resources).

ANON (1984) - Crocodiles: Proceedings of the 6th working meeting of the Crocodile Specialist Group of the Species Survival Commission of the International Union for Conservation of Nature and Natural Resources convened at Victoria falls, Zimbabwe and St. Lucia Estuary, South Africa 19 to 30 September 1982. IUCN Publ. New Ser. 219p.

ANON (1984) - International Union for the conservation of Nature and Natural Resources, Survival Service Commission Crocodile Specialist Group News letter : Editors comments. King, F. Wayne, Chairman: 3: 2: Sep., 1984. P. 1-24.

ANON (1985) - A Directory of Crocodilian Farming Operations / R.A. Luxmoore, et.al. Cambridge: IUCN, 1985. 204p.

ANON (1985) - Biology of the reptilia : development A - Vol. 14 / edited by Carl Gans, co-edited by Frank Billett and Paul F.A. New York: John Wiley and Sons. xii, 763p.

ANON (1985) - Conservation of Similipal in its Wilderness : Proceedings of National Conference on Biosphere Reserves, Similipal, Baripada, May 19-22, 1985 / edited by S.N.

Patro and M.K. Misra. Berhampur, Orissa: Orissa Environmental society, 1985. 200p.

ANON (1989) - Crocodiles: Proceedings of the 8th working meeting of the Crocodile Specialist Group of the Species Survival Commission of the International Union for Conservation of Nature and Natural Resources convened at Quito, Ecuador, 13 to 18 October 1986. IUCN (Int. Union Conserv. Nat. Nat. Resour.) Publ. New ser. 204p.

ANON (1989) - Crocodiles. Their Ecology, Management, and Conservation. A special publication of the Crocodile Specialist Group of the Species Survival Commission of the International Union for Conservation of Nature and Natural Resources. IUCN (Int. Union Conserv. Nat. Nat. Resour.) Publ. New Ser. 308p.

ANON (1990) - Crocodiles: Proceedings of the 10th working meeting of the Crocodile Specialist Group of the Species Survival Commission of IUCN - the World Conservation Union convened at Gainesville, Florida, U.S.A., 23 to 27 April 1990. IUCN/SSC Crocodile Specialist Group, Vols. 1 and 2. 699p. (Available from IUCN - The World Conserv. Union Publ. Serv. Unit, 219c Huntington Rd, Cambridge CB3 0DL, England).

ANON (1992) - Crocodile conservation action. A special publication of the Crocodile Specialist Group of the Species Survival Commission of the IUCN - the World Conservation Union. IUCN (Int. Union Conserv. Nat. Nat. Resour.) Gland, Switzerland, 128p. (Available from CSG Exec. Off., Mus. Nat. Hist., Gainesville, FL 32611).

ANON (1993) - Crocodile conservation and management in India.: 1993, P.1-27.

ANON (1994) - Crocodiles: Proceedings of the 12th working meeting of the Crocodile Specialist Group of the Species Survival Commission of IUCN - the World Conservation Union convened at Pattaya, Thailand, 2-6 May 1994. IUCN - The World Conservation Union. Vol. 1. 309p.

ANON (1994) - Crocodiles: Proceedings of the 12th working meeting of the Crocodile Specialist Group of the Species Survival Commission of IUCN - the World Conservation Union, Pattaya, Thailand, 2-6 May 1994. IUCN - The World Conservation Union. Vol. 2. 340p.

ANON (1996) - Crocodile population explosion. Crocodile Spec. Group News. 15(4): 11-12.

ANON (1996) - A Guide to Reptiles and Fishes / edited by A. Gunther. Delhi: Asiatic Publishing House, 119p.

ANON (1996) - Action plan: Biodiversity conservation in wetland habitats, Crocodilians. Report of the 1st Western Asia Regional Conference of the IUCN/SSC CSG, 5-7 June, 1997, Jiwaji University, Gwalior. 19p.

ANON (1996) - Wildlife Wealth of Orissa.— Wildlife Wing of Orissa Forest Department, 180p.

ANON (1997) - IUCN and SSC Crocodile Specialist Group Newsletter.: 16: 3, 1997. P. 1-21.

ANON (undated) - Crocodile breeding and management, India, Project findings and recommendations.— FD: DP/IND/74/046 Terminal report.

AOKI, R. (1976) - On the generic status of *Mecistops* (Crocodylidae), and the origin of *Tomistoma* and *Gavialis*. Bull. Atagawa Inst. 6-7: 23-30. [in Japanese].

AOKI, R. (1982) - The phylogeny and evolution of crocodilians. I. Kaiyoh to Seibutu (Aquabiology). 4: 122-127. [in Japanese].

ARIEL, E. S. BOWDEN and J. MILLER (1996) - Crocodile resuscitation. Crocodile Spec. Group News. 15(3): 14.

ASHLEY, D. and N.D. DENNIS (1987) - Marketing crocodilian skins. In: Webb, G., C. Manolis, and P. Whitehead (Eds.). *Wildlife Management: Crocodiles and Alligators*. Surrey Beatty and Sons, Chipping Norton, NSW, Australia. pp. 397-403.

ASTHEIMER, L.B., S.C. MANOLIS and C.R. GRAU (1989) - Egg formation in crocodiles: Avian affinities in yolk deposition. *Copeia*. 1989(1): 221-224.

ATTWELL, R.I.G. (1966) - Possible bird-crocodile commensalism. *The Ostrich*. 37: 54-55.

AVERY, R.A. (1994) - Growth in reptiles. *Gerontology*. 40(2-4): 193-199.

AXELSSON, M., C.E. FRANKLIN, R. FRITSCHÉ, G.C. GRIGG and S. NILSSON (1997) - The sub-pulmonary conus and the arterial anastomosis as important sites of cardiovascular regulation in the crocodile *Crocodylus porosus*. *J. Exp. Biol.* 200(4): 807-814.

AXELSSON, M., C.E. FRANKLIN, C.O. LOFMAN, S. NILSSON and G.C. GRIGG (1996) - Dynamic anatomical study of cardiac shunting in crocodiles using high-resolution angiography. *J. Exp. Biol.* 199(2): 359-365.

AXELSSON, M., R. FRITSCHÉ, S. HOLMGREN, D.J. GROVE and S. NILSSON (1991) - Gut blood flow in the estuarine crocodile, *Crocodylus porosus*. *Acta Physiol. Scand.* 142(4): 509-516.

AXELSSON, M., S. HOLM and S. NILSSON (1988) - Flow dynamics in the crocodilian heart. *Am. J. Physiol.* 25: R875-R879.

AXELSSON, M. and C.E. FRANKLIN (1995) - The role of the pericardium and the effects of adrenaline and changes in oxygen tension on the performance of an in situ perfused crocodile heart. *J. Exp. Biol.* 198(12): 2509-2518.

BADAM, C.C. (1973) - Skull characters of *Crocodylus biporcatus*. *J. geol. Soc. India.* 14. (1). 1973. P.40-46.

BADAM, G.L. (1988) - Quaternary faunal succession of India. *Spec. Publ. Geol. Surv. India.* 11: 277-304.

BALDWIN, J., R.S. SEYMOUR and G.J.W. WEBB (1995) - Scaling of anaerobic metabolism during exercise in the estuarine crocodile (*Crocodylus porosus*). *Comp. Biochem. Physiol. A Comp. Physiol.* 112(2): 285-293.

BANERJEE, R. (1985) - Nest guarding by estuarine crocodile - a behaviour study in the Sunderbans. *J. Bombay Nat. Hist. Soc.* 82(1): 214-215.

BANERJEE, R. (1995) - 'Rear and Release' of the estuarine crocodile, *C. porosus* in Sunderbans. *Zoos' Print.* 10(7): 16.

BANKS, E. (1931) - Some measurements of the estuarine crocodile (*Crocodylus porosus*) from Sarawak. *J. Bombay nat. Hist. Soc.* 34(4): 1086.

BARBOUR, T. (1924) - An historic crocodile skull. *Copeia.* 1924: 16.

BARROW, H.W. (1895) - Crocodiles in artificial reservoirs. *J. Bombay nat. Hist. Soc.* 10: 144.

BARTON, C.G. (1927) - Gharial in Burma. *J. Bombay nat. Hist. Soc.* 33: 450.

BASU, D. (1979) - Indien kampft um den Ganges-Gavial. *Sielmann's Tierwelt.* 3(2): 4-13.

BASU, D. (1980) - Baby crocs in a valley of death. *International Wildlife.* 10(1): 3-11.

BASU, D. (1981) - Saving the gharial. *Indian Wildlifer.* 1(1): 6-15

BASU, D. (1991) - The Gharial of Katerniaghata Sanctuary. Vol. II No. II P.36-43

BASU, D. and BUSTARD, H.R. (1981) - Maternal behaviour in the Gharial [*Gavialis gangeticus* (Gmelin)]. *J. Bombay nat. Hist. Soc.* 78(2): 390-391.

BATTYE, R.K.M. (1944) - Crocodile bellowing. *J. Bombay nat. Hist. Soc.* 45(1): 93-94.

BATTYE, R.K.M. (1945) - A crocodile's misadventure. *J. Bombay nat. Hist. Soc.* 45(): 427-428.

BAUR, G. (1886) - The poratlas, atlas and axis of the Crocodilia. *American Naturalist.* 20: 288-293.

BAYLISS, P. (1987) - Survey methods and monitoring within crocodile management programmes. In: Webb, G., C. Manolis, and P. Whitehead (Eds.). *Wildlife Management: Crocodiles and Alligators.* Surrey Beatty and Sons, Chipping Norton, NSW, Australia. pp. 157-175.

BEAKE, B. (1870) - The nest of the crocodile. *Zoologist.* 5: 2002-2004.

BEDI, R. (1982) - Corbett National Park / Ramesh Bedi. New Delhi: Saraswati Vihar, 189p.

BEDI, R. (1987) - Corbett National Park / Ramesh Bedi, translated by Ramesh Deshpande from the Original Hindi, edited by Amit Jayaram, Delhi: Clarion Books. 183p.

BEHURA, B.K. (1990) - Conservation of wildlife in Orissa, (India). In: Manna, G. K. and B. B. Jana (Ed.), *Impacts of environment on animals and aquaculture, National Symposium, Kalyani, West Bengal, India, May 14-16, 1988.* pp. 29-34,

BEHURA, B.K. and L.A.K. SINGH (1979) - Conservation of crocodiles in India. *Indian Forester.* P. 83-92.

BEHURA, B.K. and S.K. KAR (1981) - A note on egg predators of the salt-water crocodile (*Crocodylus porosus* Schneider) in Bhitarkanika Wildlife Sanctuary, Orissa. *Pranikee.* 2: 25-28.

BELLAIRS, ANGUS D'A. (1987) - The crocodilia. *Wildlife Management: Crocodiles and Alligators.* Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead, editors. p. 5-7. 1987.

BENNETT, R. AVERY (1998) - Reptile anesthesia. *Semin. Avian Exot. Pet Med.* 7(1): 30-40.

BENNETT, A.F., R.S. SEYMOUR and D.F. BRADFORD (1985) - Mass-dependence of anaerobic metabolism and acid-base disturbance during activity in the salt-water crocodile, *Crocodylus porosus*. *The Journal of Experimental Biology.* 118: 161-171.

BENTON, M.J. (1985) - Classification and phylogeny of the diapsid reptiles. *Zool. J. Linn. Soc. London.* 84: 97-164.

BENTON, M.J. and J.M. CLARK (1988) - Archosaur phylogeny and the relationships of the Crocodylia. *Syst. Assoc. Spec.* 35A: 295-338.

BENTON, M.J. (1984) - The relationships and early evolution of the diapsida. *Zool. Soc. London Symp.* 52: 575-596.

BERESFORD, W.A. (1992) - Trabeculae within the crocodilian liver. *American Zoologist.* 32(5): 138A.

BERGMANS, W. (1967) - *Crocodylus porosus* (Schneider). *Lacerta.* 22. (1963). 1967. P.11-12, 19-20.

BHADAURIA, R.S. (1977) - Last of dinosaurs-the crocodilians. *Indian Forester.* 103(4): 206-268.

BHANOTAR, R.K., R.K. BHATNAGAR and D.K. THAKUR (1974) - Export of India's wildlife and its biological significance. *Cheetal.* 16(3): 24-34.

BHASKER, S. (1981) - Travels in the Andamans and Nicobars. *Hamadryad.* 6(1): 2-8.

BHOWMICK, M.G. (1979) - Nest of Estuarine Crocodile (*Crocodylus porosus*) in their Natural Haunt in the Sunderbans. *Indian forester.* (Sp. issue on Tiger symposium), P. 78-82.

BIDDULPH, C.H. (1936) - A mugger with one foot missing. *J. Bombay nat. Hist. Soc.* 39(1): 184-185.

BIDDUPH, C.H. (1937) - A mugger (*Crocodylus palustris*) with a broken jaw. *J. Bombay nat. Hist. Soc.* 39(2): 421-423.

BIRCHARD, G.F. and D. MARCELLINI (1996) - Incubation time in reptilian eggs. *J. Zool. (Lond.).* 240(4): 621-635.

BISWAS, S. (1970) - A preliminary survey of gharial in the Koshi river. *Indian Forester.* P.705-710

BISWAS, S. (1970) - Proposals for the protection of marsh crocodile. *Indian Foresters.* 96(9): 704.

BISWAS, S. (1976) - The gharial in the Mahanadi river, Orissa. *Newl. zool. sur. India.* 2(2): 44-46

BISWAS, S. (1977) - Nesting behaviour of estuarine crocodile, *C. porosus* Schneider. *J. Bombay nat. Hist. Soc.* 74(2): 361.

BISWAS, S., L.N. ACHARJYO and S. MOHAPATRA (1977) - A note on the protuberance or knob on the snout of the male gharial [*Gavialis gangeticus* (Gmelin)]. *J. Bombay nat. Hist. Soc.* 74(3): 536-537.

BLAKE, D. K. (1992) - A basic method for the collection and incubation of crocodilian eggs. *J. Herpetol. Assoc. Afr.* No. 40. p. 97-99.

BLAKE, D. K. and J.P. LOVERIDGE (1975) - The role of commercial crocodile farming in crocodile conservation. *Biol. Conserv.* 8(4): 261-272.

BOAKE, B. (1970) - The nest of crocodile. *Zoologist.* 5(2): P.2002-4.

BOLAND, J.E. and C.J. BELL (1980). - A radio telemetric study of heating and cooling rates in unrestrained, captive *Crocodylus porosus*. *Phy. zool.* 53(3): 270-283.

BOLTON, M. (1989) - The Management of Crocodiles in Captivity / Melvin Bolton. Rome: Food and Agriculture Organization, viii, 62p. (FAO Conservation Guide, 22).

BORKAR, M.R. and M.K. MALLYA (1995) Sex determination health conditions and biometric study of captive muggers of Bondla Zoo, Goa. *Zoos' Print.* 10(7): 39-42.

BOULENGER, G.A. (1889) - Catalogue of the Chelonians, Rhynchocephalians and crocodiles in the British Museum, P.273-298.

BOULENGER, E.G. (1989) - Natural History of World Animals / E. G. Boulenger, introduction by H. G. Wells. Delhi: Akashdeep Publishing House. 268p.

BRANDER, A.A.D. (1930) - An enormous estuary crocodile. *J. Bombay nat. Hist Soc.* 34(2): 584-585.

BRANDER, D. (1925) - Stones in crocodiles' stomach. *Field.* 146: 537.

BRAZAITIS, P. (1967) - Endangered. *Animal Kingdom.* P. 123-127.

BRAZAITIS, P. (1968) - The determination of sex in living crocodilians. *British Journal of Herpetology.* 4: 54-58.

BRAZAITIS, P. (1973) - The identification of living crocodilians.—New York Zoological Society : *Zoologica.* P. 59-101.

BRAZAITIS, P. (1981) - Maxillary regeneration in a marsh crocodile, *Crocodylus palustris*. *J. Herpetol.* 15(3): 360-362.

BRAZAITIS, P. (1983) - Crocodiles as a Resource for the Tropics. *National Academy of Sciences, Washington, D.C.*

BRAZAITIS, P. (1984) - Problems in the identification of commercial crocodilian hides and products, and the effect on law enforcement. *IUCN Publ. New Ser.* p. 110-116.

BRAZAITIS, P. (1986) - Reptile leather trade: the forensic science examiner's role in litigation and wildlife law enforcement. *J. Forensic Sci.* 31: 621-629.

BRAZAITIS, P. (1986) - Biochemical techniques: new tools for the forensic identification of crocodilian hides and products. In: Proc. 7th Working Meet, IUCN/SSC Crocodile Specialist Group, Caracas, Venezuela, Oct. 21-28, 1984. pp.384-388.

BRAZAITIS, P. (1987) - The identification of crocodilian skins and products. In *Wildlife Management: Crocodiles and Alligators.* Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead, editors., p. 373-386.

BRAZAITIS, P. (1989) - The forensic identification of crocodilian hides and products. *IUCN (Int. Union Conserv. Nat. Resour.) Publ. New Ser.*, p. 17-43.

BRAZAITIS, P. (1989) - The trade in crocodilians. In: Ross, C.A (Ed.), *Crocodiles and Alligators.* Golden Press Pty Ltd, Silverwater, NSW, Australia. pp. 196-201.

- Crocodile management for profit. Presented at Seminar 'Inputs for development of aquaculture' held at andhra university waltair, visakhapatnam, Andhra Pradesh. 1981. P.

BUSTARD, H.R. and L.A.K. SINGH (1981) - Gharial attacks on man. *J. Bombay nat. Hist. Soc.* 78(3): 610-611.

BUSTARD, H.R and L.A.K. SINGH (1981) - Age at onset of sexual maturity in male Indian mugger (*Crocodylus palustris*) reared under ideal husbandry conditions in captivity. *Jour. Bombay Natur. Hist. Society*: 78: 3: 28, Dec., 1981.

BUSTARD, H.R. and S.K. KAR (1981) - Defence of the nest against many by the saltwater crocodile (*Crocodylus porosus* Schneider). *J. Bombay nat. Hist. Soc.* 77(3): 514-515.

BUSTARD, H.R. and S.K. KAR (1981) - Attack on domestic livestock by the saltwater crocodile (*Crocodylus porosus*) in Orissa, India. *Brit. J. Herpetol.* 6(). 1981. P.

BUSTARD, H.R. and S.K. KAR (1981) - Nest defence against man by the saltwater crocodile (*Crocodylus porosus*). *Bri. J. Herpetol.* 6(4): 143.

BUSTARD, H.R. and S.K. KAR (1981) - Crocodile kills takes as human food. *Brit. J. Herpetol.* 6(4): 137.

BUSTARD, H.R. and S. MAHARANA (1981) - Fatal male-male conflict in the Gharial, *Gavialis gangeticus* (Gmelin) Reptilia, Crocodilia. *J. Bomb. Nat. Hist. Society*. 78(1): 171-173.

BUSTARD, H.R. and D. BASU. (1982) - A record (?)Gharial clutch size. *J. Bombay nat. Hist. Soc.* 79(1): 207-208.

BUSTARD, H.R. and L.A.K. SINGH (1982) - An Annotated Bibliography on Indian Crocodilians. India: FO/In- dia Management project, 1982. 54p. (Field Document, no.9 FO:INO/74/046).

BUSTARD, H.R. and S.K. KAR (1982) - Crocodile predation on man. *Brit. J. Herpetol.* 6: 222-223.

BUSTARD, H.R. and S. MAHARANA (1982) - Size at first breeding in the gharial *Gavialis gangeticus* (Gmelin)(Reptilia, Crocodilia) in captivity. *J. Bombay nat. Hist. Soc.* 79(1): 206-207.

BUSTARD, H.R. and S. MAHARANA (1982) - The behaviour of the nest-guarding saltwater crocodile (*Crocodylus porosus* Schneider) - a preliminary quantitative study. *J. Bombay nat. Hist. Soc.* 79(1): 87-92.

BUSTARD, H. R. and L. A. K. SINGH (1983) - Movement of wild gharial, *Gavialis gangeticus* (Gmelin) in the river Mahanadi, Orissa (India). *Br. J. Herpetol.* 6(8): 287-291.

BUSTARD, H. R. and S. MAHARANA (1983) - Growth rates in sub-adult gharial *Gavialis gangeticus* (Gmelin) (Reptilia, Crocodilia). *J. Bombay Nat. Hist. Soc.* 80(1): 224-226.

BUSTARD, H.R. (1984) - Breeding the gharial (*Gavialis gangeticus*): captive breeding a key conservation strategy for endangered crocodilians. *Symp. Zool. Soc. Lond.* No. 52. p. 385-406.

BUSTARD, H.R. and B.C. CHOUDHURY - The distribution of the gharial. *J. Bombay nat. Hist. Soc.* P.

BUSTARD, H.R. and S. MAHARANA (in Press) - Female territoriality in immature saltwater crocodile *Crocodylus porosus* Schneider in captivity and its effects on growth and survival. *J. Bombay nat. Hist. Soc.* In press. P.

CAMPBELL, HOWARD W. (1974) - Observations on the acoustic behavior of crocodilians. *Zoologica (N.Y.)*, 58(1):1-11. 1973. From *Biol. Abstr.* 57(7),1974.

CAMPBELL, H.W. (1972) - Ecological or phylogenetic interpretation of crocodile nesting habits. *Nature*. 238. (5364). 1972. P.404-405.

CARDEILHAC, P. T., J. SCHUMACHER, R. E. LARSEN and P. MCGUIRE (1990) - Strategies to increase reproductive rates of captive crocodilians. 21st Annual IAAAM Conference, Vancouver, B.C., Ruth Francis-Floyd, editor. p. 66-69.

CARDEILHAC, PAUL T. and J. SCHUMACHER (1989) - Feed management to control disease and infertility in crocodilians. *Proc. Annu. Meet. Am. Assoc. Zoo Vet.* p. 139-147.

CARMEL, B. P. (1991) - Use of oxytocin to induce oviposition in a dystocic saltwater crocodile - *Crocodylus porosus*. *Aust. Vet. J.* 68(6): 216-217.

CARPENTER, C.D.H. (1928) - Can crocodiles swallow their food under water? *Nature*, 122: 15.

CARROLL, ROBERT L. (1985) - Evolutionary constraints in aquatic diapsid reptiles. *Spec. Pap. Palaeontol.* 33: 145-155.

CARROLL, ROBERT L. (1988) - Vertebrate Paleontology and Evolution. W.H. Freeman, San Francisco, 698 pp.

CASTANET, J. (1994) - Age estimation and longevity in reptiles. *Gerontology*. 40(2-4): 174-192.

CATCHPOLE, CLIVE K. (1979) - The Animal Family / Clive K. Catchpole, Frank H. Hucklebridge and D. Michael Stoddart, illustrated by Richard Orr and Michael Woods, introduction by Desmond Morris. London: Hamlyn, 160p.

CATER, N. (1985) - CITES gives green light to crocodile soup. *New Scientist*. 106: 8.

CHADHA, S.K. and C.S. KAR (1999) - Saltwater Crocodile conservation and management Project. In *Bhitarkanika - myth and Reality, Natraj Publishers*, Dehradun. Pp. 172-187.

CHAKRABARTI, KALYAN (1985) - Tiger (*Panthera tigris tigris*) in the mangrove forests of sunderbans : an ecological study. *Suara Alam*: Dec., P. 8-11.

CHATTERJEE, S. (1993) - Procompsognathus from the Triassic of Germany is not a crocodylomorph. *Journal of Vertebrate Paleontology*. 13(3 suppl.): 29A.

CHAVAN, S.A. (1979) - Distribution and conservation of crocodiles in and around Gir wildlife sanctuary. *Indian J. Forestry*. 2(3): 266-268.

CHAVANA-NIKUL, V., S. WATTANODORN and P. YOUNGPRAPAKORN (1994) - Karyotypes of 5 species of crocodile kept in Samutprakan Crocodile Farm and Zoo. *CSG Proceedings, Pattaya, Thailand, 2-6, May, 1994. Crocodile Specialist Group*. 1: 58-62.

CHOQUENOT, DAVID P. and GRAHAME J.W. WEBB (1987) - A photographic technique for estimating size of crocodilians seen in spotlight surveys and quantifying observer bias in estimating sizes. In: Webb, G., C. Manolis, and P. Whitehead (Eds.). *Wildlife Management: Crocodiles and Alligators*. Surrey Beatty and Sons, Chipping Norton, NSW, Australia. pp. 217-224.

CHOUDHURY, A. (1992) - Records of the gharial *Gavialis gangeticus* (Gmelin) from the Dhakuakhana area of Assam. *J. Bombay Nat. Hist. Soc.* 89(3): 380-381.

CHOUDHURY, A. (1997) - Records of the gharial *Gavialis gangeticus* (Gmelin) from the Barak River system of north-eastern India. *J. Bombay Nat. Hist. Soc.*, 94(1): 162-164.

CHOUDHURY, A. (1998) - Status of the gharial *Gavialis gangeticus* in the main Brahmaputra river. *J. Bombay nat. Hist. Soc.* 95(1): 118-120.

CHOUDHURY, B.C. and S.K. KAR (1975) - Crocodile management for profit. *Crocodile Management Group*, 1975. P. 1-1.

CHOUDHURY, B.C. (1979) - Crocodiles in India mythology. *Makara*. 1. (1). 1979. P.9-10.

CHOUDHURY, B.C. (1980) - Crocodile rearing in winter months. *Makara*. 2. (2). 1980. P.12-14.

CHOUDHURY, B.C. and H.R. BUS-TARD (1980) - Predation on natural nests of the saltwater crocodile (*Crocodylus porosus Schneider*) on north Andaman island with notes on the crocodile population. *J. Bombay nat. Hist. Soc.* 76(2): 311-323.

CHOUDHURY, B.C. (1981) - Mugger (*Crocodylus palustris*) releases in Andhra Pradesh and Tamil Nadu. *Hamadryad*. 6. (1). 1981. P.10-11.

CHOUDHURY, B.C. (1981) - Mugger releases. *Hamadryad*. 6. (3). 1981. P.9.

CHOUDHURY, B.C. (1981) - Mugger breeding in Nehru Zoological Park. *Hamadryad*. 6. (1). 1981. P.11-12.

CHOUDHURY, B.C. (1982) - Rehabilitating the endangered mugger crocodile (*Crocodylus palustris*, lesson) in India: case histories and future. Paper presented at Symposium: "Milestones in biological sciences" Utkal University, February, 1982. 1982. P.

CHOUDHURY, B.C. and H.R. BUS-TARD (1982) - Restocking mugger crocodile *Crocodylus palustris* (Lesson) in Andhra Pradesh : Evaluation of a pilot release. *J. of Bombay Natural History Society*: 79(2): 275-289.

CHOUDHARY, B.C. and R.K. RAO (1982) - Status survey of crocodile populations. *Central Crocodile Breeding and Management Training Institute (Govt. of India)*, Hyderabad, A.P.: Aug., 1982. P. 44-48.

CHOUDHURY, B. C. and H. R. BUS-TARD (1983) - Stunted growth in captive-reared gharial. *J. Bombay Nat. Hist. Soc.* 80(2): 423-425.

CHOUDHURY, B.C. and S. CHOWDHURY (1986) - Lessons From Crocodile Reintroduction project in India. *The Indian Forester*. 112: 10: oct., 1986. P. 881-890.

CHOUDHURY, B.C. and R.J. RAO (1988) - Effect of drought on the mugger crocodile population in the Jawai lake, Pali Dist. Rajasthan India. *Mimeo Spp.*

CHOUDHURY, B.C. (1990) - Indian crocodile conservation situation report: action plan for the 1990's. *Crocodiles: Proceedings of the 10th Working Meeting of the Crocodile Specialist Group, IUCN*. Vol. 2. p. 337-345.

CHOUDHURY, B.C., S.K. MUKHERJEE and R.J. RAO (1998) - Revival of conservationaction in the historical distribution range of Gharial *Gavialis gangeticus* (1998-2005). Paper presented at the 14th working meeting of IUCN/SSC CSG Group, 14-17 July, Singapore.

CHOUDHURY, R. (1986) - Mugger breeding in captivity. *Zoos' Print*. 1(9): 17.

HOUDHURY, S. (1979) - Rehabilitation of gharial in Uttar Pradesh. *Makara* 1. (1). 1979. P.7-8.

CHOWDHURY, S. (1981) - Some studies on the biology and ecology of *Gavialis gangeticus*, the Indian gharial (Crocodilia : Gavialidae). —

University of Lucknow—Doctor of Philosophy— Lucknow: University of Lucknow, 1981. 130p.

CHOWDHURY, S. (1988) - Feeding and growth of hatchlings of *Gavialis gangeticus* in captivity. *J. Bombay Nat. Hist. Soc.*, 85(2): 288-297.

CHOUDHURY, S. and RAHMANI, A.R. (1980) - Return to the wild. *Hornbill*. 3: 6-7.

CHOWDHURY, S., H. R. BUS-TARD and B. K. TANDAN (1983) - Incubation and hatching of eggs of *Gavialis gangeticus* in hatcheries. *Br. J. Herpetol.*, 6(9): 337-342.

CHRISTIAN, K., R. KENNEDY and B. GREEN (1990) - Energy and water relations of aestivating freshwater crocodiles. *American Zoologist*. 30(4): 111A.

COCHRAN, DORIS M. and J. Goin Coleman (Eds) (1970) - The new field book of reptiles and amphibians. New York: G.P.Putnam's Sons, xxii, 359p.

OHEN, M.M. and H.F. CLARK (1968) - The somatic chromosomes of five crocodilian species. *Cytogenetics*. 6: 193-203.

COHEN, M.M. and C. GANS (1970) - The chromosomes of the order Crocodilia. *Cytogenetics*. 9: 81-105.

COLBERT, E.H. (1946) - The eustachian tubes in the Crocodilia. *Copeia*. 1946(1): 12-14 (+ 1 plate).

COLE, MARY-LU (1991) - More than One Way to save a Crocodile. *The british herpetological society bulletin*. 35: 47.

COLLINS, L. (1996) - Crocodile skin production figures. *Crocodile Spec. Group Newslet.* 15(3): 15-16.

COULSON, R.A. and T. HERNANDEZ (1953) - Glucose studies in Crocodilia. *Endocrinology*. 53(3): 311-320.

CUVIER, BARON (1993) - Encyclopedia of life science : Class Reptilia / Baron cuvier. New Delhi: Anmol Publications, 1993. 110p, Vol 9.

CUVIER, G. (1831) - The animal kingdom: 9. The Class Reptilia. London: Whittaker.

'ABREU, E. (1935) - Rate of growth of the mugger (*Crocodylus palustris*, Lesson). *J. Bombay nat. Hist. Soc.* 38(1): 202.

D'ABREU, E. (1915) - Note on the mugger (*Crocodylus palustris*) contents of their stomach, folklore, etc. *J. Bombay nat. Hist. soc.* 23(4): 780.

DANI, C. S., S. R. SAGAR and L. A. K. SINGH (1991) - Mugger crocodile research at Ramatirtha: A review. *Indian Forester*. 117(10): 881-891. 1991.

DANIEL, J.C. (1969) - A review of the present status and position of endangered species of Indian reptiles. *IUCN, Eleventh Technical Meeting*, New Delhi, India: 2: 25-28, Nov., 1969. P. 75-76.

DANIEL, J.C. (1984) - A survey of the Gir national park and sanctuary 1984. P. 1-11.

DANIEL, J.C. and S.A. HUSSAIN (1973) - The record (?) saltwater crocodile (*Crocodylus porosus*). *J. Bombay nat. Hist. Soc.* 71(2): 309-312.

DANIEL, J.C. and E.M. SHULL (1963) - A list of the reptiles and amphibians of the Surat Dangs, south Gujarat. *J. Bombay nat. Hist. Soc.* 60(3): 737-743.

DANIELS, R.J. RANJIT (1995) - Notes on the status of monitor lizard and crocodiles in India. *Cobra*. 21: 6-11.

DAS, G.M. (1979) - Letter to the editor. *Indian Forester*. 105(6): 491.

DAS, G. M. (1981) - Conservation and research on gharials in Orissa. *Indian Forester*. 107(1): 42-50.

DAVENPORT, JOHN (1987) - Observations on captive juvenile salt-water crocodiles *Crocodylus porosus*. *Br. Herpetol. Soc. Bull.* 21: 51-53.

DAVENPORT, J. and M.D.J. SAYER (1989) - Observations on the aquatic locomotion of young salt-water crocodiles (*Crocodylus porosus* Schneider). *Herpetol. J.* 1(8): 356-361.

DAVENPORT, J., D.J. GROVE, J. CANNON, T.R. ELLIS and R. STABLES (1990) - Food capture, appetite, digestion rate and efficiency in hatchling and juvenile *Crocodylus porosus*. *J. Zool. Lond.* 220: 569-592.

DAVID, DENNIS N. (1994) - Harvesting wild crocodilians: guidelines for developing a sustainable use program. *Crocodiles: Proceedings of the 12th Working Meeting of the Crocodile Specialist Group of the Species Survival Commission of IUCN - The World Conservation Union, Pattaya, Thailand, 2-6 May 1994. Crocodile Specialist Group*. Vol. 1. p. 274-309.

DAVID, R. (1970) - Breeding the mugger crocodile and water monitor (*Crocodylus palustris*) and (*Varanus salvator*) at Ahmedabad zoo. *Int. zool. yrbk.* 10: 116-117.

DE KLEMM, C. and D. NAVID (1989) - Crocodilians and the law. *IUCN (Int. Union Conserv. Nat. Nat. Resour.) Publ. New Ser.* p. 80-100.

DE VOS, A. (1982) - A manual of Crocodile conservation and management in India. *Field Doc. 10. FO:IND/74/046*.

DE VOS, A. (1982) - An evaluation of the crocodile breeding and management project. *Field Working Document No 8, FAO Reports arising from the crocodile breeding and manage-*

ment project. FO:IND/74/046., July 1982. P. 1-18.

DE VOS, ANTOON (1984) - Crocodile Conservation in India. *Biological conservation*. 29: 183-189.

DE BUFFRENIL, V. (1980) - Preliminary data on the structure of growth marks among living and fossil crocodilians. *Bull. Soc. Zool. Fr.* 105(2): 355-361. [In French with English summ].

DE WAARD, J.M. (1978) - Economic potential of Indian mugger crocodile farming (*Crocodylus palustris*). FAO Reports arising from the crocodile breeding and management project. FO:IND/74/046., May 1978. P.1-24.

DE WAARD J.M. (1975) - India : Economic Potential of Gharial and Saltwater Crocodile Schemes in Orissa with Notes on the Sea Turtle Industry / J.M. De Waard. India: Food and Agriculture Organization, 1975. 124p. (FO : IND/71/033).

DE SOLA, R. (1933) - The crocodilians of the world. *Bull. New York zool. soc.* 26(1): 1-24.

DEEMING, D.C. and M.W.J. FERGUSON (1989) - The mechanism of temperature dependent sex determination in crocodilians: a hypothesis. *American Zoologist*. 29: 973-985.

DEEMING, D.C. and M.W.J. FERGUSON (1990) - Morphometric analysis of embryonic-development in *Alligator mississippiensis*, *Crocodylus johnstoni* and *Crocodylus porosus*. *Journal of Zoology*. 221: 419-439.

DENSMORE, L.D. III and R.D. OWEN (1989) - Molecular systematics of the order crocodilia. *Am. Zool.* 29(3): 831-841.

DENSMORE, L.D. III and H.C. DESSAUER (1984) - Low levels of protein divergence detected between *Gavialis* and *Tomistoma*: evidence for crocodilian monophyly? *Comp. Biochem. Physiol. B Comp. Biochem.* 77(4): 715-720.

DENSMORE, L.D. III and P. SCOTT WHITE (1991) - The systematics and evolution of the crocodilia as suggested by restriction endonuclease analysis of mitochondrial and nuclear ribosomal DNA. *Copeia*. 1991(3): 602-615.

DENSMORE, L.D. III. (1983) - Biochemical and immunological systematics of the order Crocodylia. *Evolutionary Biology*. 15: 397-465.

DERANIYAGALA, P.E.P. (1936) - A new crocodile from Ceylon. *J. Sc. sec. B. zool and geol.* 19(3): 279-286..

DERANIYAGALA, P.E.P. (1930) - The crocodiles of ceylon. *Ceylon J. Sci. Sec. B.* 16: 43-88.

DERANIYAGALA, P. (1934) - Neoteny in *Crocodylus porosus*. *Ceylon J. Sci.* 19: 97-100.

DESOLA, C.R. (1933) - The crocodilians of the world. *Bulletin of the New York Zoological Society*. 36: 3-24.

DE VOS, A. (1982) - A Manual on Crocodile Conservation and Management in India / compiled by Antoon De Vos. Dehradun: Food and Agriculture organization, 1982. 70p. (Field document, no.10).

DHARMAKUMARSINHJI, K.S. (1947) - Mating and parental instinct of the marsh crocodile (*Crocodylus palustris*, Lesson). *J. Bombay nat. Hist. Soc.* 47(1): 175.

DHARMAKUMARSINHJI, K.S. (1952) - Large stone in stomach of crocodile. *J. Bombay nat. Hist. Soc.* 50(4): 950.

DIETZ, D., F.W. KING and R.J. BRYANT (Eds) (1982) - Crocodiles: Proceedings of the fifth working meeting of the IUCN/SSC Crocodile Specialist Group, August 1980. IUCN Publ. New Ser. 409p.

DIVYABHANUSINH (1986) - Note on the strange behavior of a marsh crocodile (*Crocodylus palustris*). *J. Bombay Nat. Hist. Soc.* 83(Suppl.): 220-221.

DOWLING, H.G. (1965) - Our crocodiles like it hot. *Anim. Kingd.* 68: 74-78.

DOWLING, H.G. and P. BRAZAITIS (1966) - Size and growth in captive crocodilians. *Zoo Yrbk.* 6: 265-270.

DOWNES, M. C. (1970) - A bibliography of the recent crocodilians. *Dep. Agric. Stock Fish. Territory Papua New Guinea*. 256p. + 37p. 1970.

DOWNES, M. C. (1973) - The literature of crocodile products. *Papua New Guinea Dep. Agric. Stock Fish. Wildl. Leafl.* 73/7. i + 26p. 1973.

DRANE, C.R. (1981) - The thermal conductivity of the skin of crocodilians. *Comp. Biochem. Physiol. A Comp. Physiol.* 68(1): 107-110.

DUFAURE, J. P. and E. SAUNIER (1987) - Extra cellular matrix components of the crocodilian skin. *Am. Zool.*, 27(4): 65A. 1987. [Abstract only].

DUNSON, W.A. and FRANK J.M. (1988) - Some aspects of water and sodium exchange of freshwater crocodilians in fresh water and seawater: role of the integument. *Comp. Biochem. Physiol. A Comp. Physiol.* 90(3): 391-396.

DUNSON, W.A. (1970) - Some aspects of electrolyte and water balance in three estuarine reptiles, the diamondback terrapin, american and saltwater crocodiles. *Comp. Biochem. Physiol.* 32: 161-174.

DURLAND, D. (1990) - The trade in other exotics: their effect on the crocodilian market: ostrich and el-

ephant trade in the USA. *Crocodiles: Proceedings of the 10th Working Meeting of the Crocodile Specialist Group, IUCN*, Vol. 2, p. 334-336. 1990.

DUTTA, S.K. and L.N. ACHARJYO (1990) - Checklist of the herpetofauna of Orissa, India. *Snake*. 22(1): 36-43.

DUTTA, S.K. and L.N. ACHARJYO (1995) - Herpetofaunal Resources and their conservation in Orissa, India. *Zoos' print*. 10(7): 5-8.

EDWARDS, S.V., M. GRAHN and W.K. POTTS (1995) - Dynamics of MHC evolution in birds and crocodilians - Amplification of class II genes with degenerate primers. *Molecular Ecology*. 4(6): 719-729.

FERGUSON, H.S. (1891) - Distribution of indian crocodiles. *J. Bombay nat. Hist. Soc.* 6(1): 116-117.

FERGUSON, M.W.J. (1985) - The reproductive biology and embryology of crocodilians. In: Gans, C., F.S. Billett, and P.F.A. Maderson (Eds.). *Biology of the Reptilia*, Vol. 14. Wiley and Sons, New York. pp. 329-491.

FERGUSON, M.W.J. (1987) - Post-laying stages of embryonic development for crocodilians. *Wildlife Management: Crocodiles and Alligators*. Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead, editors. p. 427-444.

FIENNES, R.N.T. (1965) - Report of the society's pathologist for the year 1962. *Proc. zool. Soc. Lond.* 143: 53-78.

FISHER, D.C. (1981) - Crocodilian scatology, microvertebrate concentrations, and enamel-less teeth. *Paleobiology*. 7(2): 262-275.

FITCH, H.S. (1985) - Variation in clutch and litter size in new world reptiles. *Univ. Kans. Mus. Nat. Hist. Misc. Publ.*, No. 76. 76p. [Available from Publications Secretary, Mus. Nat. Hist., Univ. Kans., Lawrence 66045].

FITZERALD, S. (1989) - International Wildlife Trade : Whose Business is it? / Sarah Fitzgerald. Washington: WWF. xix,459p.

FITZGERALD, LEE A. (1989) - An evaluation of stomach flushing techniques for crocodilians. *J. Herpetol.* 23(2): 170-172.

FLAMAND, J.R., P.S. ROGERS and D.K. BLAKE (1992) - Immobilization of crocodiles. The Use of Tranquillizers in Wildlife. *Proceedings of the Wildlife Tranquillizer Symposium, National Zoological Gardens, Pretoria, South Africa, 17-18 March 1989*. H. Ebedes, editor. p. 61-65.

FLOWER, S.S. (1925) - Contribution to our knowledge of the duration of life in vertebrate animals-iii reptiles. *Proc. zool. soc. Lond.* 1925. P.911-981.

FORSYTH, H.W. (1910) - The food of crocodiles. *J. Bombay nat. Hist. Soc.* 20(1): 228-229.

FOX, E.B. (1920) - The mysterious "jhoor". *J. Bombay nat. Hist. Soc.* 27(1): 175-176.

FRANCIS, R. (1911) - The broad snouted mugger in the Indus. *J. Bombay nat. Hist. Soc.* 20(4): 1160-1162.

FRANKLIN, C.E. and G.C. GRIGG (1993) - Increased vascularity of the lingual salt glands of the estuarine crocodile, *Crocodylus porosus*, kept in hyperosmotic salinity. *J. Morphol.* 218(2): 143-151.

FRANKLIN, C.E. and M. AXELSSON (1994) - The intrinsic properties of an *in situ* perfused crocodile heart. *The Journal of Experimental Biology*. 186: 269-288.

FREY, E. (1988) - The carrying system of crocodilians - a biomechanical and phylogenetical analysis. *Stuttg. Beitr. Naturkd. Ser. A (Biol.)*. No. 426. 60p. 1988. [In German with English summ].

FREY, E. (1984) - Aspects of the biomechanics of crocodilian terrestrial locomotion. In: Reif, W.-E. and F. Westphal (Eds.). *Third Symposium on Mesozoic Terrestrial Ecosystems, Short Papers: 93-97*, Tubingen (Attempto Verlag).

FREY, E., J. RIESS and S.F. TARSITANO (1989) - The axial tail musculature of recent crocodiles and its phyletic implications. *American Zoologist*. 29(3): 857-862.

FUCHS, K.H.P., C.A. ROSS, A.C. POOLEY and R. WHITAKER. (1989) - Crocodile skin products. In: Ross, C.A. and Garnett, S. (Eds.). *Crocodiles and Alligators. Facts On File, Inc.*, New York. pp. 188-195.

GADOW, A. (1901) - Amphibia and reptilia. *The cambridge natural history* viii. 1901. P.668.

GANS, C. (1976) - Questions in crocodilian physiology. *Zool. Afr.* 11(2): 241-248.

GANS, C. and PARSONS, T. S. (EDS) (1970) - *Biology of the Reptilia*. London: Academic Press.

GARNETT, S. (1985) - Fatty acid nutrition of the estuarine crocodile *crocodylus porosus*. *Comp. Biochem. Physiol. B Comp. Biochem.* 81(4): 1033-1035.

GARNETT, S. T. (1985) - The consequences of slow chitin digestion on crocodilian diet analyses. *J. Herpetol.* 19(2): 303-304.

GARNETT, S. T. (1986) - Metabolism and survival of fasting estuarine crocodiles. *J. Zool. Ser. A (Lond.)*. 208(4): 493-502.

GARNETT, S.T. and R.M. MURRAY (1986) - Parameters affecting the

growth of the estuarine crocodile, *Crocodylus porosus*, in captivity. Aust. J. Zool. 34(2): 211-223.

GARNETT, S. (1988) - Digestion, assimilation and metabolism of captive estuarine crocodiles, *Crocodylus porosus*. Comp. Biochem. Physiol. A Comp. Physiol. 90(1): 23-29.

GASKI, A.L. and G. HEMLEY (1988) - The ups and downs of the crocodilian skin trade. Traffic (U.S.A.). 8(1): 5-16.

GATESY, S.M. (1986) - Terrestrial locomotion in crocodilians and other archosaurs. Am. Zool. 26(4): 133A. [Abstract only].

GATESY, S. M. (1987) - A functional analysis of the crocodilian hindlimb during terrestrial locomotion. Am. Zool. 27(4): 64A. [Abstract only].

GATESY, J. and G.D. AMATO (1992) - Sequence similarity of 12s ribosomal segment of mitochondrial DNAs of gharial and false gharial. Copeia. 1992(1): 241-243.

GEER, A.E. (1974) - On the maximum total length of the saltwater crocodile (*Crocodylus porosus*). J. Bombay nat. Hist. Soc. 1974. P.

GEORGE, J.C. and R.V. SHAH (1965) - Evolution of air sacs in Sauropsida. J. Anim. Morph. Physiol. 12: 255-263.

GMELIN, J.F. (1789) - Linne systema naturae. Leipzig Ed. 13. 1788. (1): 1057.

GOIN, COLEMAN J. (1978) - Introduction to herpetology. 3rd ed. San Franasco: W.H.Freeman and Co., 1978. ix,378.

GORZULA, S. (1984) - Proposal for a photographic method for size estimates of crocodilians. Herpetol. Rev. 15(2): 38-39.

GOTCH, A.F. (1986) - Reptiles : Their Latin Names Explained : A Guide to Animal Classification / A.F. Gotch. Poole: Blandford Press, 1986. 176p.

GOUDER, B.V.M. and V.B. NADKARNI (1976) - Steroidogenic cellular sites and chromaffic cells in the adrenals of some reptiles: a histochemical study. Indian J. Exp. Biol. 14(4): 391-393.

GREENFIELD, L.J. and A.G. MORROW (1961) - The cardiovascular hemodynamics of Crocodilia. J. Surg. Res. 1: 97-103.

GREER, ALLEN E., JR. (1971) - Crocodilian nesting habits and evolution. Fauna. no. 2. p. 20-28.

GREER, A.E. (1970) - Evolutionary and systematic significance of crocodilian nesting habits. Nature. 227: 523-524.

GREER, A.E. (1974) - On the maximum total length of the salt-water crocodile (*Crocodylus porosus*). Journal of Herpetology. 8(4): 378-381.

GRENDAR, STEVE (1991) - Handbook of Alligators and Crocodiles / Steve grenard.— Malabar: Krieger Publishing Company, 210p.

GRIGG, G.C. (1978) - Metabolic rate, Q10 and respiratory quotient (RQ) in *Crocodylus porosus*, and some generalizations about low RQ in reptiles. Physiol. Zool. 51: 354-360.

GRIGG, G.C. and M. GRUCA (1979) - Possible adaptive significance of low red cell organic phosphates in crocodiles. J. Exp. Zool. 209(1): 161.

GRIGG, G.C. (1981) - Plasma homeostasis and cloacal urine composition in *Crocodylus porosus* caught along a salinity gradient. J. Comp. Physiol. 144: 261-270.

GRIGG, G.C., L.E. TAPLIN, B. GREEN and P. HARLOW (1986) - Sodium and water fluxes in free-liv- ing *Crocodylus porosus* in marine and brackish conditions. Physiol. Zool. 59: 240-253.

GRIGG, G.C. (1987) - Water relations of crocodilian eggs: management considerations. Wildlife Management: Crocodiles and Alligators. Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead, editors. p. 499-502.

GRIGG, G.C. (1993) - Twenty years of wondering and worrying about how crocodiles live in salt water. Herpetology in Australia: A Diverse Discipline. Daniel Lunney and Danielle Ayers, editors. p. 265-277.

GRIGG, G. C., R. M. G. WELLS and L. A. BEARD (1993) - Allosteric control of oxygen binding by haemoglobin during embryonic development in the crocodile *Crocodylus porosus*: the role of red cell organic phosphates and carbon dioxide. J. Exp. Biol. Vol. 175. p. 15-32.

GROOMBRIDGE, B. (1987) - The distribution and status of world crocodilians. Wildlife Management: Crocodiles and Alligators. Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead, editors. p. 9-21.

GROOMBRIDGE, B. (comp.). (1982) - Estuarine or Saltwater Crocodile. In: 'The IUCN Amphibia-Reptilia Red Data Book. Part 1'. (IUCN : Gland). pp.371-390.

GROSS, R.B. (1976) - Alligators and Other Crocodilians / Ruth Belov Gross.— New York: Four Winds Press, 1976. 58p.

GRZIMEK B. (editor) (1974) - Grzimek's Animal Life Encyclopedia : Reptiles - vol.6 / edited by Bernhard Grzimek. New York: Van Nostrand Reinhold Co. 589p.

GUGGISBERG, G.A.W. (1971) - The scared crocodile. Africana. 4. (7). 1971. P.11-13.

GUGGISBERG, C.A.W. (1972) - Crocodiles : Their Natural History Folklore and Conservation / C.A.W. Guggisberg. Newton Abbot: David and Charles, 1972. x,195p.

GUPTA, R. C. and P. SRI HARI (1989) - On the basking behaviour of the mugger crocodylus palustris lesson (reptilia: crocodilia) at Bhorsainda Crocodile Sanctuary, Haryana state. *J. Bombay nat. Hist. Soc.* 86(2): 170-174.

GUPTA, R.C. and C.S. BHARDWAJ (1996) - Reproductive behaviour of indian mugger (*Crocodylus palustris*) at Bhorsaindan Crocodile Sanctuary in Haryana. *J. Bombay nat. His. Soc.* 93(1): 97-101.

GUPTA, R.C. and C.S. BHARDWAJ (1993) - Food spectrum and feeding habits of Indian mugger. *Zoos' Print.* 10(7): 28.

GUPTA, R.C. and C.S. BHARDWAJ (1995) - Burrow residency in case of crocodile (*Crocodylus palustris*). *Zoos' Print.* 8(9): 13-14.

GUPTA, R.C. and C.S. BHARDWAJ (1995) - Investigation of the tunnel ecology of *Crocodylus palustris* Lesson. *Journal of Experimental Biology.* 16(2): 167-174.

HALL, PHILIP M. (1991) - Estimation of nesting female crocodilian size from clutch characteristics: correlates of reproductive mode, and harvest implications. *J. Herpetol.* 25(2):133-141. 1991.

HARWELL, GARY M. (1986) - Problems associated with captive management of crocodilians. *Annu. Proc. Am. Assoc. Zoo Vet.* p. 122. (Abstract only).

HECHT, M.K. and B. MALONE (1972) - On the early history of the *Gavialid* crocodilains. *Herpetologica.* 28(3): 281-284.

HEMLEY, G. (1990) - Illegal trade in crocodilian skins: current problem areas. *Crocodiles: Proceedings of the 10th Working Meeting of the Crocodile Specialist Group, IUCN.* Vol. 2. p. 308-309. 1990.

HERZOG, H.A. and G.M. BURGHARDT (1977) - Vocalization in juvenile crocodilians. *Z. Tierpsychol.* 44(3): 294-304. July 1977. [In English with German summ.]

HIBBERD, E. M. A. (1994) - Systemic mycotic disease in juvenile farmed crocodiles, *Crocodylus porosus*. *Crocodiles: Proceedings of the 12th Working Meeting of the Crocodile Specialist Group of the Species Survival Commission of IUCN - The World Conservation Union, Pattaya, Thailand, 2-6 May 1994.* Crocodile Specialist Group. Vol. 2. p. 324-328.

HIBBERD, E.M.A. (1994) - Fungal disease in eggs and hatchlings of farmed *Crocodylus porosus*. *CSG Proceedings, Pattaya, Thailand, 2-6, May, 1994. Crocodile Specialist Group.* 2: 39-48.

HIBBERD, E.M.A. (1994) - Scanning electron microscopy study of fungal infection in eggs of farmed *Crocodylus porosus*. *CSG Proceedings, Pattaya, Thailand, 2-6, May, 1994. Crocodile Specialist Group.* 2: 319-323.

HOFFSTETTER, R. and G. JEAN-PIERRE (1969) - Vertebrae and ribs of modern reptiles. In *biology of the reptilia 1: Morphology A* Gans, C. and A. d'A Bellairsand T.S. Parson (Eds.) 1969. P.

HONEGGER, R.E. (1975) - The crocodilian situation in European zoos. *Int. Zoo Yrbk.* 15. 1975. P.277-283.

HONEGGER, R.E. (1982) - Breeding crocodiles in captivity, a retrospect 1960-1980. *Crocodiles: Proceedings of the Fifth Working Meeting of the IUCN/ SSC Crocodile Specialist Group.* David Dietz, F. Wayne King, and Rhoda J. Bryant, editors. p. 286-297.

HONEGGER, R.E. (1989) - Crocodilian utilization and public education: difficulties in explaining conservation. *IUCN (Int. Union Conserv. Nat. Nat. Resour.) Publ. New Ser.* p. 183-184.

HULBERT, A. J. and CRAIG A. WILLIAMS (1988) - Thyroid function in a lizard, a tortoise and a crocodile, compared with mammals. *Comp. Biochem. Physiol. A Comp. Physiol.* 90(1): 41-48.

HUSSAIN, S.A. (1991) - The ecology of gharial (*Gavialis gangeticus*) in the National Chambal Sanctuary. *M. Phil thesis, Aligarh Muslim University, Aligarh.*

HUSSAIN, S.A. and B.C. CHOUDHURY (1992) - An action plan for future gharial rehabilitation in national chambal sanctuary notes :IUCN/SSC Indian sub-continent Reptile and Amphibian Specialist Group *Zoos Print.* 7. (11). 1992. P.10-11.

HUSSAIN, S.A. (1999) - Reproductive success, hatching survival and rate of increase of gharial *Gavialis gangeticus* in National Chambal Sanctuary, India. *Biological Conservation.* 87(1999): 261-268.

HUTTON, J.M. (1987) - Techniques for ageing wild crocodilians. *Wildlife Management: Crocodiles and Alligators.* Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead, editors. p. 211-216.

INGLIS, C.M., W.L. TRAVERS, H.V. O'DONEL and E.O. SHEBBEAR (1920) - A tentative list of the vertebrates of the Jalpaiguri district, Bengal part III. *J. Bombay nat. Hist. Soc.* 27(1): 151-162.

INTERNATIONAL ZOO YEAR-BOOK (1973) - Vol. 13 / edited by Nicole Duplaix-Hall.— London: Zoological Society of London, 1973. 416p.

INTERNATIONAL ZOO YEAR-BOOK (1978) - Vol.18 / edited by

P.J.S. Olney. London: Zoological Society of London, 1978. 462p.

INTERNATIONAL ZOO YEARBOOK (1979) - Vol.19 / edited by P.J.S. Olney. London: Zoological Society of London, 1979. 450p.

INTERNATIONAL ZOO YEARBOOK (1982) - Vol.22 / edited by P.J.S. Olney. London: Zoological society of London, 1982. 488p.

IORDNASKY, N.N. (1964) - On the origin and relations of the families of the recent crocodilians. Abstracts of the Herpetological Conference 12-14 October 1964. Leningrad State Univ. 1964. P.26-28. [in Russian]

IORDANSKY, N.N. (1967) - Peculiarities of the crocodilian skull related to the feeding function and origin of Gavialidae. *Zool. Zh.* 46(4): 567-75.

IUCN (1990) - Species : Newsletter of the species survival commission IUCN- World Conservation union number 13-14 July, 1990 / edited by Karin Nelson.— Switzerland: The world conservation union, 90p.

JACKSON, J.F. and W.C. HOWARD (1974) - The feeding habits of crocodilians: validity of the evidence from stomach contents. *J. Herpetol.* 8(4): 378-381.

JACKSON, K., D.G. BUTLER and J.H. YOUSON (1996) - Morphology and ultrastructure of possible integumentary sense organs in the estuarine crocodile (*Crocodylus porosus*). *J. Morphol.* 229(3): 315-324.

JACKSON, K., D.G. BUTLER and J. YOUSON (1996) - Integumentary sense organs. *Crocodile Spec. Group Newslet.* 15(3):14-15.

Jackson, K., D.G. Butler and D.R. Brooks (1996) - Habitat and phylogeny influence salinity discrimination in crocodilians: implications for osmoregulatory physiology and historical biogeography. *Biol. J. Linn. Soc.* 58(4): 371-383.

JACOBSEN, E.R. (1982) - Captive Crocodile Health Problems: A Report. FAO. DehraDun: *Crocodile Breeding and Management Project*, 1982 23p. REPORT NO. : Field document No.11.

JACOBSON, E. (1986) - Histopathological results pertaining to some samples which Dr. Jacobson had carried with him. : (Letters to J.B. Sale).: Letters., 1986

JAYAL, N. D. (1980) - Crocodile conservation in India. *Tigerpaper.* 7(4): 1-3.

JAYARAM, K.C. (1974) - Ecology and distribution of freshwater fishes, amphibians and reptiles. In *ecology and biogeography in India*. Ed. M.S. Mani. 1974. P.

JEFFERY, J., S. VELLAYAN, P. OOTHUMAN, B. OMAR, MD. ZAHEDI, M. KRISHNASAMY and I. SINGH (1990) - Incidental post-mortem finding of the buffalo leech in the lungs of an estuarine crocodile. *J. Vet. Malays.* 2(1): 39-41. [In English with Bahasa Malaysia summ].

JELDEN, D. (1990) - Update on regulations: how international rules are changing. *Crocodiles: Proceedings of the 10th Working Meeting of the Crocodile Specialist Group, IUCN.* Vol. 2. p. 306-307.

JELDEN, D. (1990) - Appropriate solutions for the uninterrupted marking of crocodilians, their skins and leather products. *Crocodiles: Proceedings of the 10th Working Meeting of the Crocodile Specialist Group, IUCN.* Vol. 1. p. 250-267.

JENKINS, ROBERT W. G. (1987) - The world conservation strategy and cites, principles for the management of crocodilians. *Wildlife Management: Crocodiles and Alligators.* Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead, editors. p. 27-31. 1987.

John, M.C., K.S. Venkataraman, P.R. Subamaniam and P. Chakravarthy (1991) - Restraining of gharials (*Gavialis gangeticus*). *Zoos Print.* 6(5): 21.

Johnson, C.R. , G.J.W. Webb and C. Tanner (1976) - Thermoregulation in crocodilians—ii. A telemetric study of body temperature in the Australian crocodiles, */Crocodylus johnstoni/* and */Crocodylus porosus/*. *Comp. Biochem. Physiol. A Comp. Physiol.* 53(2): 143-146.

JONES, D. and L. HAYES-ODUM (1994) - A method for the restraint and transport of crocodilians. *Herpetol. Rev.* 25(1): 14-15.

JONES, S. (1891) - Harpooning crocodiles. *J. Bombay nat. Hist. Soc.* 6. (1). 1891. P.107.

JONES, D.R. (1995) - Crocodilian cardiac dynamics: a half-hearted attempt. *Physiological Zoology.* 68: 9-15.

JOSEPH, A., E. CHAUHAN, K. KHANNA and R. WHITAKER (1975) - Marsh crocodile (*Crocodylus palustris*) in the Gir. *J. Bombay nat. Hist. Soc.* 72(3): 862-3.

JOSS, J. M. P. and A. CUFF (1987) - Steroidogenesis during gonadal differentiation in the salt water crocodile, *Crocodylus porosus*. *Am. Zool.* 27(4): 66A. [Abstract only].

JUBB, T. F. (1992) - A thiamine responsive nervous disease in saltwater crocodiles (*Crocodylus porosus*). *Vet. Rec.* 131(15): 347-348.

KALYANKAR, S.D. (1977) - / *Acanthostomum slusarskii/* sp. N. (Trematoda, Acanthostomidae) from */Crocodilus palustris/* Less. in India. *Acta Parasitol. Pol.* 24(22): 227-230. [In English with Polish summ].

KANCHANAPANGKA, S. and P. YOUNGPRAPAKORN (1994) - Differential morphology of crocodilian leucocytes. *Crocodiles: Proceedings of the 12th Working Meeting of the Crocodile Specialist Group of the Species Survival Commission of IUCN - The World Conservation Union, Pattaya, Thailand, 2-6 May 1994. Crocodile Specialist Group. Vol. 1.* p. 63-71.

KANUNGO, B.C. (1976) - An integrated scheme for conservation of crocodiles in Orissa with management plans for Satkoshia Gorge and Bhitarkanika Sanctuaries. State Forest Department, Cuttack, Orissa. P.1-128.

KAR, C.S. (1985) - A gharial (*Gavialis gangeticus*) at Gahirmatha coast, Orissa, India. *J. Bombay Nat. Hist. Soc.* 82(3): 671-674.

KAR, C.S and S.K. KAR (1990) - Gharials bred in captivity at Nandankanan Biological Park. *Orissa Review.* 45(3): 13-16.

KAR, S.K. (1978) - Saltwater crocodile resources in Orissa. *Orissa Review.* 35(3): 50-52.

KAR, S.K. (1979) - Back to captivity. *Wildlife Newsletter.* 7(4): 86.

KAR, S.K. (1979) - Malformation at birth in the saltwater crocodile (*Crocodylus porosus* Schneider) in Orissa. *J. Bombay nat. Hist. Soc.* 76(1): 166-167.

KAR, S.K. (1979) - Operation saltwaer crocodile. *Wildlife Newsletter* 7(2): 35-36.

KAR, S.K. (1980) - Saltwater crocodile project, Orissa. *Makara.* 2(1): 7-8.

KAR, S.K. and H.R. BUSTARD (1980) - Sexing of the crocodiles in captivity. *Indian Forester.* 106(8): 540-545.

KAR, S.K. (1981) - Studies on the saltwater crocodile, *Crocodylus porosus* Schneider. Ph.D. Thesis, Utkal University, Orissa. 1981. P.

KAR, S.K. (1981) - Saltwater Crocodile Project assists deprived village people. *The Cent. Crocodile Brdg. and Matg. Tr. Inst. News letter.* 3(1): 8-9.

KAR, S. K. and H. R. BUSTARD (1981) - Attacks on domestic livestock by the saltwater crocodile (*Crocodylus porosus*) in Orissa, India. *Br. J. Herpetol.* 6(4): 135-136.

KAR, S.K. and H.R. BUSTARD (1981) - Defence of the nest against man by the saltwater crocodile (*Crocodylus porosus* Schneider). *J. Bombay nat. Hist. Soc.* 77(3): 514-515.

KAR, S.K. (1982) - Saltwater Crocodiles - Are they man eaters? *Orissa Review.* 38(6): 29-30.

KAR, S. K. and H. R. BUSTARD (1982) - Embryonic tail deformation in the saltwater crocodile (*Crocodylus porosus*, Schneider) in Orissa, India. *Br. J. Herpetol.* 6(6): 221-222.

KAR, S. K. and H. R. BUSTARD (1982) - Occurrence of partial albinism in a wild population of the saltwater crocodile (*Crocodylus porosus*, Schneider) in Orissa, India. *Br. J. Herpetol.* 6(6): 220-221.

KAR, S. K. and H. R. BUSTARD (1983) - Saltwater crocodile attacks on man. *Biol. Conserv.* 25(4): 377-382.

KAR, S.K. (1984) - Conservation future of the saltwater crocodile *Crocodylus porosus* Schneider in India. *IUCN Publ. New Ser.*, p. 29-32.

KAR, S.K. and H.R. BUSTARD (1985) - The status, conservation and future of the saltwater crocodile (*Crocodylus porosus* Schneider) in Orissa. *Proceedings of the symposium on endangered animals and marine parks, Edited by E.G.Silas marina Biological Assosiation of India,Cochin.* pp 1988.

KAR, S.K and H.R. BUSTARD (1985) - A decade of Saltwater Crocodile (*Crocodyles porosus* Schneider) conservation programme in Bhitarkanika Wildlife Sanctuary, Orissa, India. *Proc. Nat. Conf. Biosphere Reserve, Simplipal, Orissa.* 103-108.

KAR, S.K. and H.R. BUSTARD (1986) - A note on sighting of a sub-adult gharial (*Gavialis gangeticus*) at Gahirmatha coast of Bhitarkanika Wildlife Sanctuary. *Nature and Wildlife Conservation Society of Orissa News letter.* 4(3): 55-56.

KAR, S.K and H.R. BUSTARD (1988) - Crocodile tears. *Wildlife Today. Journal of nature and Wildlife Conservation Society of Orissa.* 1(1): 8.

KAR, S.K. and H.R. BUSTARD (1988) - Orissa-re-Kumbhira Jojanar Agargati (Progress of Crocodile Conservation Programme in Orissa). *Utkal Prasanga* 43 (7/8): 57-59. (In Oriya).

KAR, S.K. and H.R. BUSTARD (1989) - Nandankanan Gharial Kumbira. *Utkal Prasang.* 44(9): 39-40. (In Oriya).

KAR, S.K. and H.R. BUSTARD (1989) - Crocodile Conservation Programme in Orissa - An overview. *Crocodile Specialist Group Newsletter.* 8: 16-18.

KAR, S.K. and H.R. BUSTARD (1989) - Crocodile conservation programme in Orissa. *Orissa Review.* XLV(9) : 34-36.

KAR, S. K. and H. R. BUSTARD (1989) - Status of the saltwater crocodile (*Crocodylus porosus* Schneider) in the Bhitarkanika Wildlife Sanctuary, Orissa, India. *J. Bombay Nat. Hist. Soc.* 86(2): 141-150.

KAR, S.K. and H.R. BUSTARD (1990) - A Saltwater Crocodile, project and sanctuary Development in Orissa - A Case history. *Orissa Review.* (December 1990 issue).

KAR, S. K. and H. R. BUSTARD (1990) - Results of a pilot saltwater

crocodile *Crocodylus porosus* Schneider restocking in Bhitarkanika Wildlife Sancturay, Orissa. *J. Bombay Nat. Hist. Soc.* 87(2): 195-200.

KAR, S. K. and H. R. BUSTARD (1991) - Rehabilitation of saltwater crocodiles *Crocodylus porosus* Schneider in the Bhitarkanika Wildlife Sanctuary, Orissa. *J. Bombay Nat. Hist. Soc.* 88(3): 395-399.

KAR, S.K. (1992) - Captive farming of saltwater crocodiles in Bhitarkanika Sanctuary, Orissa : A prospective. *Orissa Review*. 49(4): 45-49.

KAR, S.K. (1992) - Conservation, research, and management of estuarine crocodile, *Crocodylus porosus* Schneider in Bhitarkanika Wildlife Sanctuary, Orissa. Notes :IUCN/SSC Indian Sub-continent Reptile and Amphibian Specialist Group. *Zoos Print.* 7(11) 11.

KAR, S.K. (1992) - Studies on the salt-water crocodile *Crocodylus porosus*, Schneider (Summary). *Zoos' Print.* 6(6): 8-9.

KAR, S.K and G.S. PADHI (1992) - Present status of estuarine crocodiles (*Crocodylus porosus* Schneider) in Orissa, India. *Ori-Forest (Quarterly magazine on Forestry and Wildlife-specials Wildlife issue)* Oct. Nov. 1992.

KAR, S.K. (1993) - Post hatching dispersal and growth of the saltwater crocodile {*Crocodylus porosus*} Schneider, in Orissa, India. *Journal of the Bombay Natural History Society.* 90(3): 446-450.

KAR, S.K. (1996) - Crocodile program in Orissa. *Crocodile Spec. Group News.* 15(3):7.

KAR, S.K., L.N. ACAHARJYO and S.K. PATNAIK (1998) - Rehabilitation of crocodilians in Orissa. *Cobra.* 33: 23-26.

KARILA, P., M. AXELSSON, C.F. FRANKLIN, R. FRITSCHE, I.L. GIBBINS, G.C. GRIGG, S. NILSSON and S. HOLMGREN (1995) - Neuopeptide immunoreactivity and co-existence in cardiovascular nerves and autonomic ganglia of the estuarine crocodile, *Crocodylus porosus*, and cardiovascular effects of neuropeptides. *Regulatory Peptides.* 58: 25-39.

KAUL, LALITHA, KAUL, P.L., RAO, G.S., PATEL, B.J., SABAPARA, R.H. (1991) - Spectrum of pathomorphological alterations associated with toxæmic sudden deaths in wild captive crocodiles (*Crocodylus palustris*). notes :Abstract. P.20.

Kemp, T.S. (1988) - Haemothermia or archosauria? the interrelationships of mammals, birds and crocodiles. *Zool. J. Linn. Soc.* 92(1):67-104.

KHAN, M.S., MIRZA, M.R. (1976) - An annotated checklist and key to the reptiles of Pakistan 1 : Chelonia and Crocodilia. *Biologia, Lahore.* 22. (2). P.211-219.

Khawarey, K. N. (1995) - Crocodile breeding centre at Tadoba. *Tigerpaper,* 22(3):15-16. 1995.

KIMURA, W. (1978) - Artificial incubation of gharial eggs. *Bull. Atagawa Institute Tropical and Alligator Garden.* 1978: 1-16.

King, F. Wayne, editor (1991) - Crocodilian farming: information from the scientific literature. *Crocodile Spec. Group Species Survival Comm.*, 134p. [In Spanish. Available from Crocodile Spec. Group, Fla. Mus. Nat. Hist., Gainesville 32611].

KING, F.W., DOBBS, J.S. (1975) - Crocodilian propagation in American zoos. *Int. Zoo Yrbk.* 15. P.272-277.

KING, F.W., BRAZAITIS, P. (1971) - Species identification of commercial crocodilian skins. *Zoologica.* 56. (2). 1971. P.15-75.

KING, F.W. (1971) - Internationa trade and endan- gered species. *Int. Zoo Yrbk.* 56. (2). 1971. P.21-13.

KING, F.W. (1990) - Conservation of crocodilians: the release of captive-reared specimens. *End. Species Update.* 8(1): 48-51.

KIRSHNER, D. (1985) - Environmental effects on dorsal colouration in the saltwater crocodile, *Crocodylus porosus*. In: *Biology of Australasian Frogs and Reptiles.* Gordon Grigg, Richard Shine, and Harry Ehmann, editors., p. 397-402.

KLEIN, F.R. (1863) - Beitrage zur osteslogie der krokodilschadel. *Fahresh Ver. vaterl. naturk. wurttemberg, stuttgart 16 Jahrg.* 19. P.70-100.

KLIDE, A.M., KLIDE, L.V. (1973) - Chemical restraint of three reptilian species. *J. zoo Anim. Med.* 4. (1). 1973. P.8-11.

KRISHNAMURTHY, V.S. AND BHASKARAN, R. (1980) - Some observations on the growth of captive crocodiles. *J. Bomb. nat. Hist. Soc.* 77(3): 516-521.

KRISHNAMURTHY, D.R. (1915) - Angling for crocodiles with hook and line in the Krishnarajasagar reservoir. *J. Bombay nat. Hist. Soc.* 50(1): 181-182.

KRISHNAMURTHY, V.S. AND BHASKARAN, R. (1976) - Growth studies on two species of crocodiles in captivity. *J. Bomb. Nat. Hist. Soc.*: 73: 532-533.

KRISHNAN, M. (1980) - The estuarine crocodile *Crocodylus porosus* schneider off the orissa coast. *J. Bombay nat. Hist. Soc.* 67(3): 573-574.

KUEHN, G. (1974) - Crocodilian nutritional deficiencies. *J. Zoo Anim. Med.*, 5(4): 25.

KUMAR, V. V., CHOUDHURY, B. C., SONI, V. C. (1995) - Diet of

muggers. Croc. Spec. Group News!, 14(4):6-7.

KUMAR, V. VIJAYA (1995) - Gujarat mugger studies. Croc. Spec. Group News!, 14(4):7.

KUMAR, V. VIJAYA, CHOUDHURY, B.C., SONI, V.C. (1995) - Dietary habits of the mugger (*Crocodylus palustris*) in Andhra Pradesh, south India. Hamadryad. 20: 8-12.

LADDS, P. W., BRADLEY, J., HIRST, R. G. (1996) - Providencia rettgeri meningitis in hatchling saltwater crocodiles (*Crocodylus porosus*). Aust. Vet. J., 74(5): 397-398.

LAHIRI, A. K. (1988) - Captive breeding of estuarine crocodile (*Crocodylus porosus*) in Bhagabatpur, India. Tigerpaper, 15(3): 31.

LAL, SHYAM AND D. BASU (1982) - Sexing and sex ratios of gharial (*Gavialis gangeticus*) raised in captivity. J. Bombay nat. Hist. Soc., 79(3): 688-691.

LAL, S. GROWTH RATE OF GHARIAL IN CAPTIVITY IN UTTAR PRADESH. Cheetal. 22. (3). 1981. P.39-41.

LAL, S. (1982) - Diseases in gharial juveniles. Cheetal. 23(3): 38-40.

LAL, S. (1981) - Release of gharials in natural habitat. Cheetal. 23(2): 29-32.

LAL, S. (1980) - Rearing gharials. Cheetal. 22(1/2): 16-20.

LANCE, VALENTINE A. (1987) - Hormonal control of reproduction in crocodilians. Wildlife Management: Crocodiles and Alligators. Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead, editors., p. 409-415.

LANG, J. W. (1985) - Incubation temperature affects thermal selection of hatchling crocodiles. Am. Zool., 25(4):18A.

LANG, JEFFREY W. (1987) - Crocodilian behaviour: implications for management. Wildlife Management: Crocodiles and Alligators. Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead, editors., p. 273-294.

LANG, J. W., R. K. AGGARWAL, K. C. MAJUMDAR AND L. SINGH (1993) - Individualization and estimation of relatedness in crocodilians by dna fingerprinting with a bkm-derived probe. Mol. Gen. Genet., 238: 49-58.

LANG, JEFFREY W. AND HARRY V. ANDREWS (1994) - Temperature-dependent sex determination in crocodilians. J. Exp. Zool., 270(1): 28-44.

LANG, J. W. (1979) - Crocodilian thermal behaviors: alligators vs. crocodiles. Am. Zool., 19(3): 975.

LANG, JEFFREY W., ROMULUS WHITAKER and HARRY ANDREWS (1986) - Male parental care in mugger crocodiles. Natl. Geogr. Res., 2(4): 519-525.

LANG, JEFFREY W. (1987) - Crocodilian thermal selection. Wildlife Management: Crocodiles and Alligators. Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead, editors., p. 301-317.

LANG, J.W., H. ANDREWS, AND R. WHITAKER. (1989) - Sex determination and sex ratios in *Crocodylus palustris*. American Zoologist. 29(3): 935-952.

LANGSTON, W. (1965) - Fossil crocodilians from Colombia and the cenozoic history of the crocodilain South America. Univ. Calif. Publ. Geol. Sci. 52: 1-157.

LARHAMMAR, D. AND R.J. MILNER. (1989) - Phylogenetic relationship of birds with crocodiles and mammals, as deduced from protein sequences. Molecular Biology and Evolution. 6(6): 693-696.

LEVER, JOHN (1978) - Technical guidelines for large crocodile farm design and operation. Wildl. Papua New Guinea, 78/20. ii + 38p. Dec. 1978.

LEVER, JOHN (1975) - Crocodile Industry Training Manual / John Lever, photography and Layout by Greg Mitchell.— New Guinea: A DASF Wildlife branch Publication, 1975. 71p. (Wildlife Manual No, 75/1).

LEVER, J. (1984) - Farming of crocodiles as a conservation technique. In: Burgin, S. (ed.) 'Endangered Species : Social, Scientific, Economic and Legal Aspects in Australia and the South Pacific'. Total Environment Centre, Sydney. pp. 213-218.

LEWIS, E.S. (1940) - Crocodiles and wild boar. J. Bombay nat. Hist. Soc. 41. 1940. P.903.

LIST OF WILDLIFE DIVISION PUBLICATIONS.: June, 1979.

Living fossils.— New York: Springer-verlag, 1984. xi,291. (Case books in earth sciences).

LOVERIDGE, JOHN P. and DAVID K. BLAKE (1987) - Crocodile immobilization and anaesthesia. Wildlife Management: Crocodiles and Alligators. Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead, editors., p. 259-267. 1987.

LOVERIDGE, A. (1945) - Reptiles of the Pacific world. The infantry journal Mus. comp. zool. Harvard. 1945. P.

LOWIS, R.M. (1915) - Gharial (*Gavialis gangeticus*) and porpoise (*Platanista gangetica*), catching in the Indus. J. Bombay nat. Hist. Soc. 23. (4). 1915. P.779.

LUXLEY, T.H. (1859) - on the dermal armour Jacare and Caiman with notes on the specific and generic characters of recent crocodilia. J. Linn. Soc. iv. (). 1859. P.1-28.

LUXMOORE, RICHARD (1990) - International crocodilian skin trade: Trends and sources. *Crocodiles: Proceedings of the 10th Working Meeting of the Crocodile Specialist Group*, IUCN., Vol. 2. p. 302-305. 1990.

LYDEKKER, R. THE ROYAL NATURAL HISTORY. Fredrick wame, London and New York. V. 1896. P.30-31.

LYDEKKER, R. (1986) - Indian tertiary and post tertiary vertebrata, Siwalik crocodilia, lacertilia and ophidia. *Mem. geol. surv. India, Palaeont indica* 10. (3). 1986. P.209-240.

MADRAS SNAKE PARK TRUST (1976) - Madhya Pradesh gharial survey. *Newsl. Madras Snake Park Trust*. I. (2). 1976. P.2-3.

MADSEN, M. (1994) - Enumeration of salmonellae in crocodile pond water by direct plate counts and by the MPN technique. *Water Research*. 28: 2035-2037.

MAGNIFICENT INDIAN WILDLIFE : Vivekananda Kendra Patrika / edited by M. Lakshmi Kumari.—Kanyakumari: Vivekananda Kendra, 1987. viiib, 178p.

MAGNUSSON, WILLIAM E. (1984) - Economics, developing countries and the captive propagation of crocodilians. *Wildl. Soc. Bull.*, 12(2):194-197. 1984.

MAGNUSSON, WILLIAM E. (1979) - Maintenance of temperature of crocodile nests (Reptilia, Crocodylidae). *J. Herpetol.*, 13(4):439-443. 15 Nov. 1979.

MAGNUSSON, WILLIAM E. (1979) - Dispersal of hatchling crocodiles (*Crocodylus porosus*) (REPTILIA, CROCODILIDAE). *J. Herpetol.*, 13(3):227-231. 1979.

MAGNUSSON, WILLIAM E. (1983) - Size estimates of crocodilians. *J. Herpetol.*, 17(1):86-88. Mar. 1983.

MAGNUSSON, WILLIAM E. (1982) -Techniques of surveying for crocodilians. *Crocodiles: Proceedings of the Fifth Working Meeting of the IUCN/SSC Crocodile Specialist Group*. David Dietz, F. Wayne King, and Rhoda J. Bryant, editors., p. 389-403. 1982.

MAGNUSSON, W.E. and J. TAYLOR. 1980. A description of developmental stages in *Crocodylus porosus* for use in aging eggs in the field. *Aust. Wildl. Res.* 7: 479-485.

MAGNUSSON, W.E. and J. TAYLOR 1981) Growth of juvenile *Crocodylus porosus* as affected by season of hatching. *J. Herpet.* 15: 242-245.

MAHAPATRA, S., LN ACHARYA and B. Mishra. Catching and transferring adult Gharials (*Gavialis gangeticus*) : Letter.—*Indian Forester*: 102: 9, 1976. P. 636-637.

MAHARANA, S. and H. R. BUSTARD (1982) - Behaviour of the male gharial during the nesting and post-hatching period. *J. Bombay nat. Hist. Soc.*, 79(3):677-681. Dec. 1982.

MALHOTRA, A.K. (1975) - HNAD-rearing of crocodile (*Crocodylus palustris*, Lesson) at Delhi zoological park. *Cheetal*. 17. (1). 1975. P.44-45.

MANOLIS, S. C., G. J. W. WEBB, D. PINCH, L. MELVILLE and G. HOLLIS (1991) - Salmonella in captive crocodiles (*Crocodylus johnstoni* and *C. porosus*). *Aust. Vet. J.*, 68(3):102-105. 1991.

MANOLIS, S. CHARLIE, GRAHAME J. W. WEBB and KAREN E. DEMPSEY (1987) - Crocodile egg chemistry. *Wildlife Management: Crocodiles and Alligators*. Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead, editors., p. 445-472. 1987.

MANSHARMANI, D.K. (1966) - Cranial peculiarities of *Gavialis gangeticus* with special reference to foramina, fossa and vacuities. *Proc. Indian Acad. Sci.* 64B. (6). 1966. P.320-333.

MARAIS, J. and G. A. SMITH (1990) - Croclit: A computerized catalogue of crocodilian literature. *J. Herpetol. Assoc. Afr.*, No. 38. p. 42-43. 1990.

MARTIN, B. G. H. and A.D'A BELLAIRS (1977) - The narial excrescence and pterygoid bulla of the gharial (*Gavialis gangeticus*) (Crocodylia). *J. Zool. (Lond.)*, 182(4):541-558. Aug. 1977.

MASKEY, T.M., H.F. PERCIVAL and C.L. ABERCROMBIE (1995) - Gharial habitat use in Nepal. *J. Herpetol.* 29(3): 463-464.

MATHEW, C. JOHN, KS VENKATARAMAN and V CHAKRABORTY (1991) - Blood collection in gharial (*Gavialis gangeticus*). Notes :Abstract. 1991. P. 25.

MATHUR, P.N., and P.C. HURKAT (1973)-The heart and the conducting system of *Gavialis gangeticus* (Gemlin). *Acta morph. lung.* 21. (2). 1973. P.137-148.

MATHUR, P.N. (1971) - The heart and the conducting (connecting) system of *Crocodylus porosus* (Schneider). *J. Anim. Morph. Physiol.* 18. ,1971. P.84-90.

MATHUR, R and K.SHARMA. (1992) - The study on the eggshell of *Gavialis gangeticus* during incubation period. Notes :IUCN/SSC Indian sub-continent Reptile and Amphibian Specialist Group Zoos Print. 7. (11). 1992. P.11.

MAZZOTTI, F.J. AND W.A. DUNSON. 1989. Osmoregulation in crocodilians. *American Zoologist*. 29(3): 903-920.

McCANN, C. (1935) - The mugger (*Crocodylus palustris*, Lesson) feeding on large water beetles. *J. Bombay nat. Hist. Soc.* 38. (2). 1935. P.409.

McCANN, C. (1938) - The reptiles and amphibians of Cutch state. *J. Bombay nat. Hist. Soc.* 40. (3). 1938. P.425-427.

McCANN, C. (1940) - A reptile and amphibian miscellany. *J. Bombay nat. Hist. Soc.* 41. (4). 1940. P.742-747.

MCINERNEY, J. (1994) - Liver enzymes and pathology in runt crocodiles (*C. porosus*). In: Junge, R.E. (Ed.). *Proceedings of the American Association of Zoo Veterinarians and Association of Reptilian and Amphibian Veterinarians Annual Conference, October 22-27, 1994.* pp. 57-58.

MEEK, A. 1911. On the morphogenesis of the head of the crocodile. *J. Anat. Phys.* 45: 357-377.

MEHROTRA, ANIL. (1997) - See you in a while, baby crocodile. *Srishti*. 1997. P.32-36.

MENON, A.K. (1980) - Saving the crocodile. *India Today October 1980*. 1980. P.16-31.

MESSEL, HARRY and DEAN R. STEPHENS (1980) - Drug immobilization of crocodiles. *J. Wildl. Manage.*, 44(1):295-296. Jan. 1980.

MEYER, E. R. (1988) - Criteria for the amphibious life: Crocodilians as examples. *Am. Zool.*, 28(4):74A. 1988. Abstract only.

MISHRA, DINESH (1982) - Crocodile Farming as a Commercial Venture.— Dehradun: *Indian Forest College*, 1982. 28p. Guide : Sood, V.K.

MISHRA, R.N. (1969) - The endangered crocodiles in India. *Cheetal* 12. (1). 1969. P.143-148.

MISHRA, B.S. (1980) - Where crocodiles are reared. *Dharmayug* 7/12/80(In Hindi). P.

MISRA, P. R., D. KUMAR, G. M. PATNAIK, R. P. RAMAN and A. SINHA (1993) - Bacterial isolates from apparently healthy and diseased crocodiles (*Gavialis gangeticus*). *Indian Vet. J.*, 70(1):375-376. 1993.

MISRA, P.R., S.K. PATRA, H.K., MOHAPATRA, K.C. PATRA, and S MOHAPATRA (1996) - aetiopathological findings from young gharial mortality cases. *The Indian veterinary journal*. 73. (8). 1996. P.888-889.

MISRA, P. 1994. Bhitarkanika: imperilled paradise. *Sanctuary Asia (Bombay)*. 14(2): 14-27.

MOHAN, R.L. LAL, J JEYASEELAN (1998) - The marsh crocodile *crocodylus palustris* of pechiparai dam of kanyakumari district. *Zoos Print*. 13. (2). 1998. P.43-44.

MOHANTY, J., S.B. TRIPATHY and L.N. ACHARJYO (1980) Prolapse of the genitals including prolapse of cloaca in male Gharial (*Gavialis gangeticus*): A clinical case Report. *Indian Vet. J.*: 57(4): 347-349.

MOHANTY-HEJMADI, P., S.K. DUTTA, D. DEY, D.P. RATH, R.L. RATH and S.KAR (1999) Temperature-dependent sex determination in the salt-water crocodile, *Crocodylus porosus* Schneider. *Current Science*. 76(5): 695-696.

MOHAPATRA, S., L.N. ACHARJYO and MISHRA, B. (1979) Breeding pool for saltwater crocodile (*Crocodylus porosus*). *Indian forester*. 105. (1). 1979. P.86-87.

MOHAPATRA, S., L.N. ACHARJYO and MISHRA, B. (1976) Catching and transferring adult gharials (*Gavialis gangeticus*). *Indian Forester*. 102. (9). 1976. P.636-637.

MOIDART. 1895. Turtle killing young crocodile. *J. Bombay nat. Hist. Soc.* 10: 153.

MONTAGUE, J. JEROME (1983) - A new size record for the saltwater crocodile (*Crocodylus porosus*). *Herpetol. Rev.*, 14(2):36-37. June 1983.

MONTEATH, J. (1923) - Catching crocodiles. *J. Bombay nat. Hist. soc.* 29. 1923. P.300-301.

MOOK, C.C. (1921) - Skull characters of recent crocodilia, with notes on the recent genera. *Bull. Amer. Mus. natu Hist.* 44. 1921. P.123-268.

MOOK, C.C. (1934) - The evolution and clarification of the crocodilia. *J. Geol.* 42. (3). 1934. P.295-304.

MORESBY, (1977) - Port Letter from Port Moresby.—*Far Eastern Economic Review*: Aug. 5, 1977, 1977. P. 54.

MORGAN, DAVIES A.M. (1980) - Translocating crocodiles.—*ORYX*: 15: 4: Aug. 1980. P. 371-373.

MUKHERJEE, A.K. (1974) - Some examples of recent faunal improvishment and regression. In *ecology and biogeography in India* 1974. P.330-368.

MURTHY, T. S. N. and R. S. PILLAI (1986) - Crocodiles. *Wildlife Wealth of India (Resources and Management)*. Trilok Chandra Majupuria, editor., p. 256-260. 1986.

MURTHY, T.S.N., MENON, A.G.K. (1977) - Conservation and utilization of the crocodilian fauna of India. *Indian Forester*. 103. (6). 1977. P.389-394.

NARAYAN, M.C. JAIPRAKASH, SHARMA, R.K., MATHUR, R. (1994) - A study on the distribution and nesting pattern of gharial (*Gavialis gangeticus*) in National Chambal Sanctuary. *Zoos Print*. 10. (1). 1994. P.61-64.

NATARAJAN, V. and S. BALACHANDRAN (1990) - Marsh

crocodile *Crocodylus palustris* (Lesson) at Point Calimere, Tamil Nadu. *J. Bombay nat. Hist. Soc.*, 87(2):307-308. 1990.

NEILL, W.T. (1971) - The last of the ruling reptiles: alligator, crocodiles and their kin. *Columbia univ. press, Ithaca*. 1971. P.486.

NEWSLETTER of the Central Crocodile Breeding and Management Training Institute, Hyderabad.—*Makara*: 1: 1: Oct., 1979. P. 1-10.

NICHOLS, JAMES D. (1987) - population models and crocodile management. *Wildlife Management: Crocodiles and Alligators*. Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead, editors., p. 177-187. 1987.

NILSSON, S. (1994) - The crocodilian heart and central hemodynamics. *Cardioscience*. 5(3): 163-166.

NOSO, TOYOHICO, VALENTINE A. LANCE, AND HIROSHI KAWAUCHI. 1995. Complete Amino Acid Sequence of Crocodile Growth Hormone. *General and comparative endocrinology*. 98(3): 244-252.

O'BRIEN, TIMOTHY G. (1990) - A comparison of three survey methods for estimating relative abundance of rare crocodilians. *Crocodiles: Proceedings of the 10th Working Meeting of the Crocodile Specialist Group, IUCN*, Vol. 2. p. 91-108. 1990.

OLSEN, S.J. (1968) Miocene vertebrates and North Florida shorelines. *Palaeogeog*. P.127-134

OZA, G. M. (1975) - Conservation of the crocodile in the sayaji sarovar lake, baroda, india. *Biol. Conserv.*, 7(3):235-236. Apr. 1975.

Oza, G.M. (1978) - Indian wildlife and human civilization.—*Indian J. of Forestry*: 1: 1, 1978. P. 25-30.

Palmer, Joan Reptiles and Amphibians / Joan Palmer.— Poole: Blandford, 1983. 94p.

PANDAV, B. (1998) - A survey of saltwater crocodile (*Crocodylus porosus*) nests in the Bhitarkanika Wildlife Sanctuary, Orissa. *Cobra*. 33: 35-40.

PARRISH, J. MICHAEL (1987) - The origin of crocodilian locomotion. *Paleobiology*, 13(4):396-414. 1987.

PARSHAD, BAINI. (1914) - The gharial (*Gavialis gangeticus*). *J. Bombay nat. Hist. Soc.* 23: 369.

PATNAIK, B.K. (1994) - Ageing in reptiles. *Gerontology*. 40 (2-4): 201-220.

PATNAIK, S.K. and L.N. ACHARJYO (1985) Wildlife conservation in Orissa, *Cheetal*. 27(1and2): 38-44.

PATNAIK, S.K. and L.N. ACHARJYO (1989) Reptiles of the Nandankanan Biological Park, Orissa. *Zoo's print*. 4(6): 2-3.

PERUTZ, M.F., C. BAUER, G. GROS, F. LECLERCQ, C. VANDECASSERIE, A.G. SCHNEK, G. BRAUNITZER, A.E. FRIDAY, and K.A. JOYSEY. 1981. Allosteric regulation of crocodilian haemoglobin. *Nature*. 291: 682-684.

PETZOLD, H.G. (1974) - zum aussterben verurteilt? über den gagenwarigen status und die überlebenschancen der panzeretrschen. *Aquarier Terrar. Mschr. Ornith. Vivar.* 20. (6). 1974. P.192-197.

PHELPS, ROBYN L., ROBERT E. GATTEN, JR., and ARNOLD T. MOSBERG (1992) - A new method for obtaining electrocardiograms in unrestrained crocodilian reptiles. *Lab. Anim. Sci.*, 42(1):73-75. 1992.

PHELPS, F. M. IV. (1992) - Optimal sex ratio as a function of egg incubation temperature in the crocodilians. *Bull. Math. Biol.*, 54(1):123-148. 1992.

PILLAI, K.G. MOHANAN - The Crocodile story. WWF for nature India.—*Souvenir— Kerala state committee*. P. 71-74.

PILLAI, K.G.M. (1982) - Some useful date on the Project. *Central Crocodile Breeding and Management Training Institute (Govt. of India)*, Hyderabad, A.P.: Aug., 1982. P. 64-79.

PITMAN, C.R.S. (1924) - The length attained by and the habit of the gharial (*Gavialis gangeticus*). *J. Bombay nat. Hist. Soc.* 30. 1924. P.703.

PITMAN, C.R. (1913) - Marsh crocodile (*Crocodylus palustris*) killing a panther (*felis pardus*). *J. Bombay nat. Hist. Soc.* 22. (2). 1913. P.641.

PITMAN, C.R. (1913) - The contents of a marsh crocodile's (*crocodylus palustris*) stomach. *J. Bombay nat. Hist. Soc.* 22. (3). 1913. P.641.

PITMAN, C.R.S. (1942) - The amazing muscular reflexes of a dead crocodile. *Uganda Journal*. 9: 81.

POE, STEVEN (1996) - Data set incongruence and the phylogeny of crocodilians. *Syst. Biol.*, 45(4):393-414. 1996.

POOLEY, TONY (1991) - Techniques for raising crocodiles in remote areas. *Crocodilian Farming: Information from the Scientific Literature*. F. Wayne King, editor., p. 81-109. 1991. In Spanish.

POOLEY, TONY (1982) - Discoveries of a Crocodile Man / Tony Pooley.—London: William Collins Sons and Co Ltd, 1982. 213p.

POOLEY, TONY (1990) - Basic crocodile farming/ranching methods in remote areas. *Crocodiles: Proceedings of the 10th Working Meeting of the Crocodile Specialist Group*,

ROSS, F. D. and C.M. GREGORY (1983) - On the dorsal armor of the crocodilia. *Advances in Herpetology and Evolutionary Biology*. Anders G. J. Rhodin and Kenneth Miyata, editors., p. 305-331. 1983.

ROSS, J.P. (Editor) (1998) - Crocodiles. Status Survey and Conservation Action Plan. 2nd Edition. IUCN/SSC Crocodile Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. viii + 96 pp.

ROSS, P. (1992) - Crocodile specialist group: medicinal use of crocodilians. Species (Newsl. Species Survival Comm.), No. 19. p. 49. 1992.

SABALE, A. B., and G. VIJAYASARATHI (1986) - Crocodilian remains from the Miocene of Kachchh, India. *J. Geol. Soc. India*. 27: 405-410.

SAGAR, S. R. and LALA A. K. SINGH (1990) - Rehabilitation of mugger crocodile (*Crocodylus palustris*) in Simlipal tiger reserve, Orissa, India. *Crocodiles: Proceedings of the 10th Working Meeting of the Crocodile Specialist Group, IUCN*, Vol. 2. p. 188-200. 1990.

SAGAR, S.R, LAK Singh (1992) - Notes on survival efficiency and growth of hatchlings mugger (*Crocodylus palustris*). *Zoos Print*. 7. (3). 1992. P.18-19.

SAGAR, S. R. and L. A. K. SINGH (1993) - Captive breeding and rehabilitation of mugger crocodile (*Crocodylus palustris*) in Simlipal tiger reserve, Orissa, India. *Indian For.*, 119(10):807-815. 1993. In English with Hindi summ.

SAHNI, ASHOK, and BRAHMA NAND TIWARI. 1979. Lower Siwalik vertebrates from Kalagarh District, Pauri Garhwal, U.P. *Himalayan Geol.* 9: 339-347.

SAHNI, MULK RAJ, and EHSANULLAH KHAN (1988) - Pleistocene vertebrate fossils and pre-history of India. Books and Books, New Delhi. 80 pp. (85 plates).

SAHNI, A., M.C. SRIVASTAVA, and R. D'SOUZA. (1978) - Eocene ziphodont Crocodilia from north-western India. *Geobios*. 11: 779-785.

SAINT-GIRONS, H. (1985) - Histology of the orbital glands of crocodilia and testudines in relation with lepidosauria. *Ann. Sci. Nat. Zool. Biol. Anim.*, 7(4):249-264. 1985. In French with English summ.

SAISANGI, P.P. - A preliminary note on the siwalik vertebrates of Jammu, Udhampur and Ramnagar areas of J&K State. *Indian Miner*. 18. (). 1964. P.91.

SALE, J.B. - Background notes on sexing and ageing, capture and marking of Indian wildlife species.—*Wildlife Institute of India*, Dehradun.

SANYAL, PRANABES. (1983) - Mangrove Tiger land the Sunderbans of India.—*Tiger paper*. 10: 3, 1983. P. 1-4.

SAXENA, RAJIV. (1992) - Unusual nesting site of mugger {*crocodylus palustris*} in Madhav national park. *J. Bombay nat. Hist. Soc.* 89. (1). 1992. P. 132-133.

SAXENA, RAJIV. (1994) - Interaction between mugger (*Crocodylus palustris*) and wild boar (*Sus scrofa*). *Cobra*. (18). 1994. P.23-24.

SAXENA, R. (1994) - Observation on the status of mugger of Madhav national park. *Zoos' Print*. 9(11): 8.

SCHMIDT, K.P. (1944) - CROCODILES. *Fauna*. 6. (3). 1944. P.67-72.

SCHNEIDER. - *Historiae amphibiorum naturalist literariae fasciculus secundus continens crocodilos scincos chamaesauras, boas, pseudoboas, elapes, angues, amphisbaenas et caecilias. Jenae*.

1801. P.

SCHULTZE, W. (1914) - Notes on the nesting place of *crocodylus palustris* lesson. *Phillippines journal of Science*. 9. (). 1914. P.313-315.

SEDGWICK, A. (1965) - Student textbook of zoology. Central Book DepotAllahabad, India. P.1-705

SELVAM, N.P. (1995) - Gastro-enteritis and its treatment in salt-water crocodiles. *Zoos' Print*. 10(9): 43.

SELVAM, N.P., R. THIRUTHALINATHAN, D. SWAMINATHAN and G. PRABHAKAR (1995) - *Escherichia coli* as disease causing organism in salt-water crocodiles. *Zoos' Print*. 10(2): 39.

SEN, PRASANTA K., AND MANJU BANERJEE (1984) - On the occurrence of reptilian remains in the peat bed of Barrackpore, 24-Parganas, West Bengal. *J. Palaeontol. Soc. India*. 29: 47-51.

SEYMOUR, ROGER S., GRAHAME J.W. WEBB, ALBERT F. BENNETT, AND DAVID F. BRADFORD. (1987) - Effect of capture on the physiology of *Crocodylus porosus*. In: Webb, G., C. Manolis, and P. Whitehead (Eds.). *Wildlife Management: Crocodiles and Alligators*. Surrey Beatty and Sons, Chipping Norton, NSW, Australia. pp. 253-257.

SEYMOUR, R.S., A.F. BENNETT, AND D.F. BRADFORD (1985) - Blood gas tensions and acid-base regulation in the salt-water crocodile, *Crocodylus porosus*, at rest and after exhaustive exercise. *The Journal of Experimental Biology*. 118: 143-159.

SHAH, S.P. (1975) - Save the gharial *Wildlife December* 1975. 1975. P.554-555.

SHAH, S.P. (1974) - Gharial (*Gavialis gangeticus*) and marsh crocodiles

Crocodylus palustris Cheetal. 16. (1). 1974. P.

SHAHI, S.P. (1977) - Backs to the wall : Saga of wildlife in Bihar, India / S.P. Shahi.— New Delhi: Affiliated East West Press, 1977 159p.

SHANKAR, K., C.V.N.K. RAO (1994) - First report of a fossil marsh crocodile Crocodile palustris from the Manneru valley, Andhra Pradesh. Current science. 67. (9 and 10). 1994. P.685-687.

SHARMA, H.D. (1991) - Limnological studies of aquatic ecosystems in Gwalior region with reference to Crocodile habitat. M.Phil thesis, Jiwaji University, Gwalior, M.P.

SHARMA, M.S. (1977) - Report on the survey of Gavial (Gharial) *Gavialis gangeticus* (Gmelin) in the Narayani River System. Report for H.M.G Ministry of Forests, National Parks and Wildlife Office, Kathmandu. P.1-12

SHARMA, R. K. (1985) - Results of 1981 survey for gharial (*Gavialis gangeticus*) in north national chambal sanctuary. *J. Bombay nat. Hist. Soc.* 82(1):215-218. 1985.

SHARMA, R.K. (1993) - Annual gharial census in National Chambal Sanctuary (1992-93). *J. Trop. Ecol.* 9(1): 90-93.

SHARMA, R.K. (1995) - Gharial census in National Chambal Sanctuary. *Journal of tropical forestry*. 11. (2). 1995. P.159-161.

SHARMA, R.K., SHARMA, SANJAY, MATHUR, R. (1995) - Wildlife survey in Madhya Pradesh - II Survey report on Ken river gharial sanctuary. *J. Freshwater bio.* 7. (1). 1995. P.59-62.

SHARMA, R.K. and SANJAY SHARMA, (1997) - Wetland faunal survey of some gharial sanctuary in Madhya Pradesh. *Indian Forester*. 123. (10). 1997. P.952-957.

SHARMA, R.K., R. MATHUR and S. SHARMA (1995) - Status and distribution of fauna in National Chambal Sanctuary, Madhya Pradesh. *Indian Forester*. 121. (10). 1995. P. 912-916.

Sharma, R.K., R. Mathur, M.D. Mishra, 1997) - Nesting biology of gharial (*Gavialis gangeticus*) in National Chambal Sanctuary. *Cobra*. 30. 1997. P.9-12.

SHARMA, SHRUTI (1993) - Tourism Management Plan / Shruti Sharma.— Dehradun: VII, 1993. 211p.

SHARMA, UDAY R. (1995) - Trans-boundary conservation issues of Nepal. *Tigerpaper*, 22(3):18-20. 1995.

SHORTT, W.H.O. (1923) - A few hints on crocodile shooting. *J. Bombay nat. Hist. Soc.* 28. (1). 1923. P.76-84.

SHUTE, C.C.D. and A.D'A. BELLAIRS. (1955) - The external ear in Crocodilia. *Proceedings of the Zoological Society of London*. 124: 741-749.

SILL, W.D. (1968) - The zoogeography of the Crocodilia. *Copeia*. 1968(1): 76-88.

SILL, W.D. Nota preliminar sobre un nueva garial del pliocene de venewuela y una discussion de los gaviales sudamericanos. *Ameghiniana* 1970. 1991. P.151-159.

SIMCOX, A.H.A. (1905) - The crocodile, its food and muscular vitality. *J. Bombay nat. Hist. Soc.* 16. (). 1905. P.375-376.

SIND. (1922) - Crocodile shooting and snaring. *J. Bombay nat. Hist. Soc.* 28: 809-811..

SINGH, L.A.K. (1975) - Studies on the Indian Gharial *Gavialis gangeticus* (Gmelin) (Reptilia, Crocodilia) IX

Observations on the development and fate of egg tooth.—*Parkruti-Utkal University Journal - Science*: 12: 1 and 2, 1975. P. 89-95.

SINGH, L.A.K. (1976) - Crocodile research in India. *Science Today*. 10. (8). 1976. P.6.

SINGH, L.A.K. (1976) - Gars and gharials. *Science Reporter*. 13. (8). 1976. P.497-8.

SINGH, L.A.K. (1976) - Hatching gharial in Orissa. *Tigerpaper*. 3. (3). 1976. P.20-21.

SINGH, L.A.K. (1976) - REARING GHARIAL IN CAPTIVITY. *Newsletter of the Madras snake park trust*. 1. (2). 1976. P.5-6.

SINGH, L.A.K. (1976) - Save the crocodiles. *Science Reporter*. 13(9): 539-542.

SINGH, L.A.K. (1976) - The future of the Indian gharial, *Gavialis gangeticus*. *Brit. J. Herpetol.* 5. (7). 1976. P.590.

SINGH, L.A.K. (1976) - When back to the Wild : rehabilitation of captive reared Gharial Juveniles.— *Cheetal*: 18, (1-2), 1976, 20-23p.

SINGH, L.A.K. (1977) - Conservation of nature and future of mankind (man and crocodile). *Tigerpaper* 4. (2). 1977. P.16-17.

SINGH, L.A.K. (1977) - Do crocodiles eat people? *Chinkara October* 1977. 1977. P.12-14.

SINGH, L.A.K. (1977) Gharial feeding. *Hornbill (Bombay Nat. Hist. Soc. pub.)*. 1977: 20-21.

SINGH, L.A.K. (1978) - Crocodile projects in Orissa. *Souvenir, 3rd All India Symposium on Endocrinology*, Bhubaneshwar. 1978. P.69-72.

SINGH, L.A.K. (1978) - Ecological studies on the Indian gharial (*Gavialis gangeticus* (Gmelin)) (reptilia,

crocodilia). Ph.D. Thesis, Utkal University, Orissa. 1978. P.

SINGH, L.A.K. (1978) - Gharial conservation in Orissa. *Indian Forester*. 104: 12, 1978. P. 823-829.

SINGH, L.A.K. (1979) - Bride crocodile from nature mates groom in captivity. *Wildlife Newsletter, Dehradun* 7 (2) : 32 also in *Indian forester* 105(7):54. 7. 105. (2). (7). 1979. P.32. 54.

SINGH, L.A.K. (1979) - Communal Use of village ponds by the mugger crocodile (*Crocodylus palustris*), cattle and man Paper presented at a symposium on "Endangered animals and their conservation" 26-27 Feb 1979, Utkal university. 1979. P.

SINGH, L.A.K. (1979) - Crocodile conservation in Orissa. Paper presented at Symposium on Endangered animals and their conservation, 26-27 February 1979, Utkal University. 1979. P.

SINGH, L.A.K. (1979) - Crocodiles make jobs for villager. *IUCN Bulletin* 10. (11). 1979. P.

SINGH, L.A.K. (1979) - Function of the ghari or gharial excrescence in the gharial (*Gavialis gangeticus*). Paper presented at the symposium: Endangered animal and their conservation, 26-27 February 1979, Utkal University. 1979. P.

SINGH, L.A.K. (1979) - Gharial research and conservation. *Wildlife Newsletter, Dehradun*, January 1979. 1979. P.7-8.

SINGH, L.A.K. (1979) - Oh! for cannibalism. *Science Gem* II. II. (1). 1979. P.47-50.

SINGH, L.A.K. (1979) - Pigeon catching mugger. *Hornbill*. 10. (). 1979. P.22-25.

SINGH, L.A.K. (1979) - Reaction to night spotting in the Gharial, *Gavialis gangeticus* (Gmelin).—*J. Bombay nat. Hist. Soc.* 76: 2, 1979. P. 367-368.

SINGH, L.A.K. (1979) - Sexual attraction of a wild mugger (*Crocodylus palustris*) Lesson toward captive mugger. *J. Bombay nat. Hist. Soc.*: 76: 1, 1979. P. 167-172.

SINGH, L.A.K. (1980) - Half a decade of gharial conservation in Orissa. *Makara*. 2. (1). 1980. P.15-16.

SINGH, L.A.K. (1980) - Sanctuary management as a tool in rural development. Paper presented at a symposium on "Wildlife resources for rural development" held at Hyderabad, India, 7-11 July 1980. 1980. P.

SINGH, L.A.K. (1981) - Gharial is a fish eating crocodile. *Science Reporter*. 18. (2). 1981. P.98-102.

SINGH, L.A.K. (1981) - Indian crocodile.—*Science Spectrum*: Feb., 1981. P. 99- 102.

SINGH, L.A.K. (1981) - Trap used for catching a Mugger (*Crocodylus palustris*) from nature.—*J. Bombay nat. Hist. Soc.*: 79: 3, 1981. P. 684-688.

SINGH, L.A.K. (1982) - Biodata of Indian Crocodiles. *Central Crocodile Breeding and Management Training Institute* (Govt. of India), Hyderabad, A.P.: Aug., 1982. P. 9-11.

SINGH, L.A.K. (1982) - Male or female in reptiles—a conservation enigma. *Science Reporter*. 21(2): 80-81.

SINGH, L.A.K. (1982) - Studies on Indian crocodiles during the past twentyfive years.—*Prakruti Journal of the Zoological Society of Orissa*: 3: 3, 1982. P. 2-3.

SINGH, L.A.K. (1983) - The Indian mugger, *Crocodylus palustris* Lesson, (Reptilia, Crocodylia): Observation on the behaviour of a female from nature. *J. Bombay nat. Hist. Soc.* 80(3): 499-506.

SINGH, L.A.K. (1983) - Feeding prescriptions for captive management of gharial, *Gavialis gangeticus* (Reptilia, Crocodylia). *Indian Forester*. 109(5): 296-305.

SINGH, L.A.K. (1983) - Communal use of village ponds by the mugger crocodile (*Crocodylus palustris*), cattle and man. *J. Bombay nat. Hist. Soc.* 80(3):642-645. 1983.

SINGH, L.A.K. (1983) - Observation on food requirements and food conversion in the mugger (*Crocodylus palustris*) reared in captivity. *J. Bombay nat. Hist. Soc.* 80(2): 410-423.

Singh, L.A.K. (1983) OBSERVATION ON THE MOVEMENT OF TWO CAPTIVE REARED MUGGER CROCODILES, *CROCODYLUS PALUSTRIS* LESSON, WHEN RETURNED TO THE WILD. *J. Bombay nat. Hist. Soc.* 80(1): 86-90.

SINGH, L.A.K. (1984) Crocodiles : Status and Management. In :*Wildlife wealth of India*. (Ed T.C. Majuparia). Tecpress Service, Bangkok, 261-275.

SINGH, L.A.K. (1984) - Developments in Crocodilian Research and Management. *Wildlife Institute of India*.—Dehradun: Food and Agriculture Organization, 1984. iii,123p. (Field Document No., I FO : IND/82/003).

SINGH, L.A.K. (1984) - Summary statement on Research Projects : National Chambal Sanctuary : 1983-84. CRC/NCS/12-A. Field camp of the Crocodile Research Centre wildlife Instt. of India (Government of India) Deari, Madhy Pradesh.

SINGH, L.A.K. (1984) - Situation report: India Central Crocodile Breeding and Management Project IUCN Publ. New Ser., p. 165-170. 1984.

SINGH, L.A.K. (1984) The Indian Mugger, *Crocodylus palustris* lesson (Reptilia, Crocodylia) : observations

on the behaviour of a female from nature.—*J. Bomb. Nat.Hist. Society.*: 80: 3, 1984. P. 499-506.

SINGH, L.A.K. (1985) - Gharial population trend in National Chambal Sanctuary with notes on radio-tracking. *Study Report Dec. 1985. Crocodile Research Centre, Wildlife Institute of India, Hyderabad.* 167 vii pp with 3 plates, 10 Figs., 21 tables.

SINGH, L.A.K. (1985) - International Conference on Crocodile Conservation and Management Jan 14-18, 1985.— Morena: Crocodile Research Centre, May 1985. 67p. (Participation report CRC/NLS/22-A May 1985).

SINGH, L.A.K. (1985) - Role of Crocodilians in nature and management of crocodilian fauna in Orissa.— *Symposium on Conservation of Environment with special emphasis on Wildlife in Orissa organised by the Zoological Society of Orissa*: March, 1985, 1985.

SINGH, L.A.K. (1986) - Crocodiles: status and management. *Wildlife Wealth of India (Resources and Management)*. Trilok Chandra Majupuria, editor., p. 261-275. 1986.

SINGH, L.A.K. (1987) - Public involvement in the Indian crocodile conservation programme. *Wildlife Management: Crocodiles and Alligators*. Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead, editors., p. 233-237. 1987.

SINGH, L.A.K. (1989) - Residual yolk and crocodilian survival. *Zoo's Print*, p. 1-2. Dec. 1989.

SINGH, L.A.K. (1989) - A note on vitamin E and *Gavialis gangeticus*. *Zoos' Print*. 4(12): 21.

SINGH, L.A.K. (1990) - A framework for sustainable use and conservation of Orissa's wetland resource. Paper presented at the Symposium on Environmental priorities of Orissa. Bhubaneswar, July 1990. *National Environmental Science Academy, Orissa Chapter*.

SINGH, L.A.K. (1990) - Indian Mugger (*Crocodylus palustris*) Lesson (Reptilia, Crocodilia) Territorial Resource Partitioning and its implication in Sanctuary management. A Zoo Project under Animal Management Courses, National Extension College, Cambridge, U.K.

SINGH, L.A.K. (1991) - Dull and difficult exhibits-no longer. (Guest Editorial). *Zoos' Print*. vol.vi(6).

SINGH, L.A.K. (1991) - Distribution of *Gavialis gangeticus*. *Hamadryad*, 16(1-2):39-46. 1991.

SINGH, L.A.K. (1991) - Vitamin E for possible improvement in breeding performance of *Crocodylus palustris*. *Zoos' Print*. 6(6): 10-12.

SINGH, L.A.K. (1991) - Non-Survival of Gharial, *Gavialis gangeticus* (Gmelin) (Reptilia, Crocodilia, Gavialidae) in river Mahanadi, Orissa. *Technical Report, December 1991. Wildlife Wing, Forest and Environment Deptt. Govt. of Orissa.* 69 pp.

SINGH, L.A.K. (1992) - Distribution of *Gavialis gangeticus*. *Hamadryad*. 16(1,2): 39-46.

SINGH, L.A.K. (1992) - Ecological studies in Indian gharials. *Zoos' Print*. 7(3): 23-25.

SINGH, L.A.K. (1992) - Nonsurvival of gharial, *Gavialis gangeticus* in mahanadi river of Orissa, India NOTES :IUCN/SSC Indian sub-continent Reptile and Amphibian Specialist Group *Zoos Print*. 7. (11). 1992. P.9-10.

SINGH, L.A.K. (1993) - New Strategy to Save Crocodiles. *Down to Earth*. March, 31, 1993: 46-47.

SINGH, L.A.K. (1993) - An introductory study of gharial (*Gavialis gangeticus*) in river Mahanadi, Orissa. *Zoo-Zen*. 8(7): 43.

SINGH, L.A.K. (1993) - IUCN/SSC Action Plans on Elephants and Crocodilians relevant to Orissa. *Oriforest*, Oct-Dec. 1992: 31-33.

SINGH, L.A.K. (1994) - Wildlife Research in Orissa— A review. pp26-49. In: *Regional Workshop on the co-ordination and monitoring of wildlife research*, 30th Sept., 1994: Review papers and suggested research priority criteria. *Wildlife Institute of India*, 146pp.

SINGH, L.A.K. (1995) - Escape and recapture of mugger at Ramatirtha. *Crocodile Specialist Group, Newsletter*. 14(3): 7.

SINGH, L.A.K. (1995) - Food of gharial, *Gavialis gangeticus*. *Zoos' Print*. 10(7): 24-27.

SINGH, L.A.K. (1995) - Congenital eye defects in *Crocodylus palustris*. *Zoos' Print*. 10(9): 46.

SINGH, L.A.K. (1998) Kumbhira Sangrakhyanara Bahubidha Pratyarpana. *Pragativadi*. 24.8.98:6 (in Oriya)

SINGH, L.A.K. - Central crocodile breeding and management project : Situation, Report, India. Government of India, *Central Crocodile breeding and management training Institute, Bahadurpura, Hyderabad*.

SINGH, L.A.K. and B.C. CHOUDHURY (1979) - Indian Crocodiles-Conservation and Research.: Jan.— *Proceedings of the First Indian crocodile researchers symposium Katerniyaghat, Uttar Pradesh, India*, 21-25 Jan.1979, 1979. P. 1-48.

SINGH, L.A.K. and B.C. CHOUDHURY (1982) Indian Crocodiles—conservation and Research. *Proceedings of the first Indian Crocodiles Researcher's symposium, Katerniyaghat, Uttar Pradesh*,

India, Forum of crocodile researchers, India.

SINGH, L.A.K. and H.R. BUSTARD (1977) - A method to identify individual young gharial (*Gavialis gangeticus*). *Brit. J. Herpetol.* 5(9): 669-671.

SINGH, L. A. K. and H.R. BUSTARD (1977) - Locomotory behaviour during basking and spoor formation in the gharial (*Gavialis gangeticus*). *Br. J. Herpetol.*, 5 (9): 673-676. Dec. 1977.

SINGH, L.A.K. and H.R. BUSTARD (1977) - Studies on the Indian gharial *Gavialis gangeticus* (Gmelin)(reptilia-crocodilia)-v: preliminary observation on maternal behaviour. *Indian Forester*. 103. (10). 1977. P.671-678.

SINGH, L.A.K. and H.R. BUSTARD (1982) - Congenital defects in the gharial *Gavialis gangeticus* (Gmelin). *Brit. J. Herpetol.* 6. (). 1982. P.215-219.

SINGH, L.A.K. and H.R. BUSTARD (1982) - Geographical distribution of the Gharial *Gavialis gangeticus* (Gmelin) in Orissa, India.—*British Journal of Herpetology*: 6, 1982. P. 259-260.

SINGH, L. A. K. and H.R. BUSTARD (1982) - Growth and behaviour of a blind gharial *Gavialis gangeticus* (Gmelin). *J. Bombay nat. Hist. Soc.* 79(3):681-684. Dec. 1982.

SINGH, L.A.K. and H.R. BUSTARD (1982) - The Extinction of the Gharial (*Gavialis gangeticus* (Gmelin)) from the Brahmani and Baitarani rivers of Orissa. *J. Bombay nat. Hist. Soc.*: 79: 2, 1982. P. 424- 426.

SINGH, L. A. K. and H.R. BUSTARD (1982) - The snout of the gharial *Gavialis gangeticus* (Gmelin). *Br. J. Herpetol.*, 6(7):253-258. Dec. 1982.

SINGH, L.A.K. and H.R. BUSTARD (1983) Movement of wild gharial *Gavialis gangeticus* (Gmelin) in River Mahanadi, Orissa, India. *British Journal of Herpetology*. 6(8): 287-291.

SINGH, L.A.K. and R.J. RAO (1986) - Significance of residual egg-fluid to hatching patterns in the Gharial (*Gavialis gangeticus*) and emydid freshwater turtles (Reptilia : Crocodilia and Chelonia).- *J. Bombay nat. Hist. Soc.* 83: 1, 1986. P. 217-220.

SINGH, L. A. K. and R. J. RAO (1990) - Territorial behaviour of male gharial *Gavialis gangeticus* in the National Chambal Sanctuary, India. *J. Bombay nat. Hist. Soc.*, 87(1):149-151. 1990.

SINGH, L.A.K. and S.D. ROUT (1995) Twinning abnormality in *Crocodylus palustris* (Reptilia, Crocodilia). *Zoos' Print*. July 1995:37-38.

SINGH, L.A.K. and S.D. ROUT (1998) Environment enrichment conditions and their preference by hatchling mugger (*Crocodylus palustris*). *Zoos Print*. 13. (1). 1998. P.6-8.

SINGH, L.A.K., S.K. DIXIT, and R.K. SHARMA (1984) - Wildlife in National Chambal Sanctuary.—In *Souvenir 6th All India Congress of Zoology*: Oct. 1984: Gwalior.

SINGH, L.A.K. and S.K. KAR (1991)- Results and recommendations relating to an assessment study on feasibility of releasing five thousand captive reared mugger crocodiles in Tamilnadu, April 1991.

SINGH L.A.K, S.K. KAR and B.C. CHAUDHARY (1984) India: Status of wild crocodilians. Paper presented in the 7th working meeting of the IUCN/SSC Crocodile Specialist Group, held at Caracas, Venezuela, 21-28 Oct. 1984.

SINGH, L.A.K, S.K. KAR and B.C. CHAUDHARY (1984) - Indian Crocodilians : A 10 years review of management. Paper presented in the 7th working meeting of the IUCN/SSC Crocodile Specialist group, held at Caracas, Venezuela. 21-25 Oct. 84.

SINGH, L.A.K. AND S.P. RAY-CHAUDHURY (1973) - DNA replication pattern in the chromosomes of *Crocodylus palustris* Lesson. *Nucleus, Calcutta*. 16. (1). P.33-37.

SINGH, L.A.K. and S.R. SAGAR (1990) - The escape and capture of a mugger crocodile(*Crocodylus palustris*) at Ramatirtha, Orissa. *Indian Forester*. 116(10): 847-849.

SINGH, L.A.K. AND S.R. SAGAR (1991) - Vitamin E for possible improvement in breeding performance of {*Crocodylus pallustris*}. *Zoos Print*. 6. (6). 1991. P. 10-12.

SINGH, L.A.K. AND S.R. SAGAR (1992) - Prolonged egg incubation and congenital tail deformities in *Crocodylus palustris* (Reptilia : Crocodilia). *J. Bombay nat. Hist. Soc.* 89. (2). P. 194-198.

SINGH, L.A.K., B.C. CHAUDHURY, AND S. KAR (1985) - Report on Study Tour on Participation of the Indian Delegation at the 7th Working Meeting : IUCN/Species Survival Commission Crocodile Specialists Group held in Caracas, Venezuela (South America) Oct. 21-28,1984.—Morena: Field camp of the Crocodile Research Centre, 1985 56p. (CRC/NLS/22).

SINGH, V.B. (1975) - Crocodile rehabilitation schemes in Uttar Pradesh. *Cheetal*. 17. (2). P.47-48.

SINGH, V.B. (1978) - Status of the gharial in uttar pradesh and its rehabilitation. *J. Bombay nat. Hist. Soc.* 75. (3). P.668-683.

SINHA, R. P., B. K. ROY AND S. P. CHAUDHARY (1987) - Gastroenteritis in a crocodile (*Crocodylus palustris*). *Indian Vet. J.*, 64(1):69-70.

SINHA, R. P., J. P. SOMAN, G. J. JHA, A. PRASAD, H. V. S. CHAUHAN AND R. S. PRASAD (1988) - An outbreak of escherichia coli enteritis in crocodiles. *Indian J. Anim. Sci.*, 58(3):338-340. 1988.

SJONGREN, S.J. (1945) - Über die embryona lentwicklung des sauropsidenmandens acta anta Acta. anta. suppl. 2. P.1-223.

SMITH, CRAIG A. and JEAN M.P. JOSS. (1994) - Uptake of 3H-Estradiol by Embryonic Crocodile Gonads During the Period of Sexual Differentiation. *Journal of Experimental Zoology*. 270(2): 219-224.

SMITH, CRAIG A. AND JEAN M. P. JOSS (1994) - Steroidogenic enzyme activity and ovarian differentiation in the saltwater crocodile, *Crocodylus porosus*. *Gen. Comp. Endocrinol.*, 93(2):232-245.

SMITH, E. NORBERT (1979) - Behavioral and physiological thermoregulation of crocodilians. *Am. Zool.*, 19(1):239-247. 1979.

SMITH, G. A. AND J. MARAIS (1994) - Stress in crocodilians - the impact of nutrition. *Crocodiles: Proceedings of the 12th Working Meeting of the Crocodile Specialist Group of the Species Survival Commission of IUCN - The World Conservation Union, Pattaya, Thailand, 2-6 May 1994. Crocodile Specialist Group*, Vol. 2. p. 2-38. 1994.

SMITH, M.A. (1929) - The survival of the gharial (*Gavialis gangeticus*) in Burma. *J. Bombay nat. Hist. Soc.* 33. (4). 1929. P.995-998.

SMITH, M.A. (1928) - Distribution of the mugger. *J. Bombay nat. Hist. Soc.* 33: 721.

SMOOTHBORE. (1897) - Crocodile. *J. Bombay nat. Hist. soc.* 11: P.151-158.

SMUTS, G.L. (1978) - Interrelation between predators prey and their environment. *Biosciences*: 28, (5), 1978, P.316-320

SOLMU, GODFRID (1996) - 1996 Crocodile trade enforcement. *Crocodile Spec. Group NewsL*, 15(4):14.

SONDHI, K.C. The hyoid and associated structures in some indian reptiles. *Anim. zool.* 2: P.157-159.

SPINAGE, C.A. (1978) - Syllabus for training in crocodile and sanctuary management. *FAO Reports arising from the crocodile breeding and management project. FO:IND/74/046*. October 1978. 1978. P.1-50.

SRIVASTAVA, A.K., BUSTARD, H.R. (1995) - Phylogeny and zoogeography of the gharial, *{Gavialis gangeticus}* (Gmelin) (Reptilia, Crocodilia). *J. Bombay nat. Hist. Soc.* 92. (2). 1995. P. 230-233.

SRIVASTAVA, A.K. (1980) - Wild mugger baby in captivity at katerniaghata. *Makara*. 2. (1): 6.

SRIVASTAVA, A.K. (1981) - Biology of indian gharial *Gavialis gangeticus* with special reference to its behaviour. *Ph.D. Thesis, University of Lucknow, Uttar Pradesh*.

SRIVASTAVA, A.K., BUSTARD, H.R. (1995) - Studies on geographical distribution and conservation of indian gharial, *{Gavialis gangeticus}* (Gmelin) (Reptilia Crocodilia). *Indian Journal of Forestry*. 18(1): 13-17.

SRIVASTAVA, A.K., BUSTARD, H.R. (1995) - Phylogeny and zoogeography of the gharial, *{Gavialis gangeticus}* (Gmelin) (Reptilia, Crocodilia). *J. Bombay nat. Hist. Soc.* P. 230-233

STACY, B. (1998) - The trouble with the high density: Veterinary Aspect of the Madras Crocodile Bank Trust. *In Proceedings of 14th Working Meeting of CSG, 13-17th July, 1998, Singapore*. P.407-410.

STATON, MARK A. (1978) - "Distress calls" of crocodilians—whom do they benefit? *Am. Nat.*, 112 (984): 327-332. Mar.-Apr. 1978.

STEEL, RODNEY (1989) - Crocodiles / Rodney Steel. London: Christopher Helm, 1989. x,198p.

STEWART, P. (1988) - Techniques for photographic size estimations of crocodilians. *Herpetological Review*. 19(4): 80-82.

SUBARAO, M.V. (1977) - On breeding crocodiles. *Science Today October 1977*.

SUBBA RAO, M. V. (1981) - Sex determination in living crocodilians. *Tigerpaper*, 8(1):10. Jan. 1981.

SUBBA RAO, M. V. (1987) - Incubating eggs of the gharial (*Gavialis gangeticus*) for conservation purposes. *Wildlife Management: Crocodiles and Alligators*. Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead, editors., p. 503-505.

SUBBA RAO, M.V. (1988) - Breeding, conservation and management of the Indian endangered crocodiles. *Proc. World Conf. Breeding Endangered Species Captivity*, No. 5. p. 555-569.

SUBBA RAO, M.V. (1991) - Bioresources : Conservation and Management (Proceedings of the UGC sponsored National Level Short term Institute for Wildlife Ecology and Management of living Resources, 1986 / M.V. Subba Rao.— Visakhapatnam: Andhra University, 162p.

SUBBA RAO, M.V. AND H.R. BUSTARD (1979) - Eggs and hatchlings of the gharial, *Gavialis gangeticus* Gmelin (Gavialidae, Crocodilia, Reptilia). *Comp. Physiol. Ecol.* 4. (2). P.114-115.

SUBBA RAO, M.V. AND H.R. BUSTARD (1980) - Observation on the hatching sequence of the Indian gharial

Gavialis gangeticus, Gmelin. Comp. Physiol. Ecol. 5. (4): 343-345.

SUBBA RAO, M.V. AND H.R. BUSTARD (1979) - Sequence of hatching of the blind baby gharial, *Gavialis gangeticus* Gmelin (Gavialidae, Crocodilia, Reptilia). Comp. Physiol. Ecol. 4. (2). P.113.

SUBHEDAR, NISHIKANT, N. S. RAMA KRISHNA AND P. D. PRASADA RAO (1989) - Cytoarchitectonic pattern of the hypothalamus in the crocodile, *Gavialis gangeticus*. Cell Tissue Res., 255(1):89-105.

SUBRAMANYAN, T.V. (1934) - Angling of crocodiles. J. Bombay nat. Hist. Soc. 37: 739.

SUNDARESAN, SIVA R, DANIELS, R.J.R. (1994) - Distribution od abundance of the common garden lizard {calotes versicolor} in the madras crocodile bank. J. Bombay nat. Hist. Soc. 91(2): 268.

SUNEJA, I. J., and SANJEEV. (1983) - On the *Gavialis* and another reptilian find from Nagrota Formation (Late Pliocene) of Jammu Sivaliks, India. Publ. Cent. Adv. Stud. Geol. N. S. 13: 133-137.

SWITZERLAND.(1984) - International Union for Conservation of Nature and Natural Resources Crocodiles : Proceedings of the 6th Working Meeting of the Crocodile Specialist Group of the Species Survival Commission of the International Union for Conservation of Nature and Natural Resources.— Switzerland: IUCN, 1984. ix,219p. (IUCN Publication New Series).

SWITZERLAND.(1989) - International Union for Conservation of Nature and Natural Resources Crocodiles : Proceedings of the 8th Working Meeting of the Crocodile Specialist Group of the Species Survival Commission of the International Union for Conservation of Nature and Natural Resources Convened at Quito, Ecuador 13 to 18 October 1986 / International Union for Conservation of Nature and Natural Resources.— Switzerland: IUCN, 1989. xiv,204p. (IUCN Publication New Series).

SWITZERLAND.(1989) - International Union for Conservation of Nature and Natural Resources Crocodiles : Supplement to the Proceedings of the 8th Working Meeting of the Crocodile Specialist Group of the Species Survival Commission of the International Union for Conservation of Nature and Natural Resources 13 to 18 October 1986 / International Union for Conservation of Nature and Natural Resources.— Switzerland: IUCN, 1989. iv,90p. (IUCN Publication New Series).

SWITZERLAND. (1973) - International Union for Conservation of Nature and Natural Resources Crocodiles : Proceedings of the Second Working Meeting of Crocodile Specialists With the Support of the National Park, Game and Fish Preservation Board and the New York Zoological Society Held at Ndumu and Lake St. Lucia, Zululand 20-27 March 1973 / International Union for Conservation of Nature and Natural Resources.— Switzerland: IUCN, 1973. 115p. (IUCN Publication New Series Supplementary Paper No. 41)

TAGUCHI, H. (1920) - Beitrage zur kenntnis über die feinere struktur der eingeweideorgane der krokodile. Mitt. med. fak. Tokio. Univ. 25: 110-188.

TAMMAR, A.R. (1980) - Bile salts in reptilia. In chemical zoology (Eds. M. Florkin and B.T. Scheer). 5(4): 337-352.

TAPLIN, LAURENCE (1988) - Osmoregulation in crocodilians. Biol. Rev. Camb. Philos. Soc., 63(3):333-377.

TAPLIN, LAURENCE E. (1985) - Sodium and water budgets of the fasted estuarine crocodile, *Crocodylus porosus*, in sea water. J. Comp. Physiol. B Biochem. Syst. Environ. Physiol. 155(4):501-513.

TAPLIN, LAURENCE E. AND GORDON C. GRIGG (1981) - Salt glands in the tongue of the estuarine crocodile *Crocodylus porosus*. Science, 212(4498):1045-1047.

TAPLIN, L. E. AND J. P. LOVERIDGE (1988) - Nile crocodiles, *crocodylus niloticus*, and estuarine crocodiles, *Crocodylus porosus*, show similar osmoregulatory responses on exposure to seawater. Comp. Biochem. Physiol. A Comp. Physiol. 89(3):443-448.

TAPLIN, LAURENCE E. (1984) - Drinking of fresh water but not seawater by the estuarine crocodile (*Crocodylus porosus*). Comp. Biochem. Physiol. A Comp. Physiol., 77(4):763-767.

TAPLIN, L.E. (1984) - Homeostatis of plasma electrolytes, water and sodium pools in the estuarine crocodile, *Crocodylus porosus*, from fresh, saline and hypersaline waters. Oecologia (Berlin). 63(1): 63-70.

TARSITANO, SAMUEL F., EBERHARD FREY AND JURGEN RIESS (1989) - The evolution of the crocodilia: a conflict between morphological and biochemical data. Am. Zool., 29(3):843-856.

TARSITANO, S. F. (1984) - Cranial metamorphosis and the evolution of the crocodilia. Am. Zool., 24(3):64A. 1984. Abstract only.

TAYLOR, JANET A., WEBB, G. J. W. AND MAGNUSSON, W. E. (1978) - Methods of obtaining stomach con-

tents from live crocodilians (Reptilia, Crocodylidae). *J. Herpetol.*, 12(3): 415-417.

TAYLOR, GREG C., CRAIG E. FRANKLIN, AND GORDON C. GRIGG. (1995) - Salt Loading Stimulates Secretion by the Lingual Salt Glands in Unrestrained *Crocodylus porosus*. *J. Exp. Zool.* 272(6): 490-495.

THE IUCN AMPHIBIA-REPTILIA RED DATA BOOK PART I (1982)

- Testudines Crocodylia Rhynchocephalia / compiled by Brian Groombridge. Switzerland: IUCN, 1982. xlivi,426p.

THE CAPTURE AND CARE MANUAL (1993) - Capture, Care, Accommodation and Transportation of Wild African Animals / Edited by Andrew A. McKenzie, foreword by Ian Player.— South Africa: Wildlife Decision Support Services CC, 1993. 729p.

The possible relationship between embryo orientation, opaque banding and the Dehydration of albumen in crocodile eggs.—COPEIA: 1, 1987. P. 252-257.

The Encyclopedia of Reptiles and Amphibians / edited by Tim R. Halliday and Kraig Adler.— London: George Allen and Unwin, 1986. xvi,143p.

The Care and Breeding of Captive Reptiles / edited by Simon Townson...et.al.— London: British Herpetological Society, 1980. 98p.

The Indian forester : Special issue on Wildlife management Vol.112 Oct. 1986 no.10.— Dehradun: FRI, 1986, Oct. 135p.

THEOBALD, W. (1980) - Catalogue of the reptile of british burma, embracing the provinces of pegu, martaban and terassserim, with descriptions of new or little known species. *J. Linn. Soc. zool.* 10: 4-67.

THORBJARNARSON, JOHN B. (1990) - Notes on the feeding behavior of the gharial (*Gavialis gangeticus*) under semi-natural conditions. *J. Herpetol.*, 24(1):99-100.

THORBJARNARSON, JOHN, MESSEL, HARRY, KING, F. WAYNE AND ROSS , JAMES PERRAN (1992) - Crocodiles: An Action Plan for their Conservation. Gland: IUCN, 1992. 136p.

THORBJARNARSON, JOHN B. (1996) - Reproductive characteristics of the order Crocodylia. *Herpetologica*, 52(1):8-24.

Tidal Waterways on the South-Western Coast of the Gulf Carpentaria : Limmen Bight, Towns, Roperss, Phelp and Wilton Rivers, Nayaranpi, wungguliyanga, painnyilatya, mangkurdwungku and yiwapa creeks / H. Messel...et.al.— Oxford: Pergamon Press, 1980. 84p. (Surveys of tidal river systems in the northern territory of Australia and their crocodile population).

TITEIN-NOLTHENIUS, A.C. (1934) - Exploitation of wildlife (Ceylon). *J. Bombay nat. Hist. Soc.* 37(1): 219-220.

TRIPATHY, S.B., RAO, A.T., PATNAIK, K.C., ACHARJOY, L.N., SINGH,L.A.K., RATH, R.L. (1983) - Investigation into the mortality of *Gavialis gangeticus* (Gmelin) hatchlings in Gharial Research and Conservation Unit, Tikerpada, Orissa (India). *Indian J. Anim. Hlth.* 22(1): 71-75.

TRIVADY, A.N. (1966) - A note on the finding of vertebrate fauna in the surma series of tripura and its bearing on the stratigraphy of the area. *Curr. Sci.* 35: 68-69.

TURTON, J. A., LADDS, P. W., MELVILLE, L. F. (1996) - Interdigital subcutaneous emphysema ('bubble foot') in *Crocodylus porosus* hatchlings. *Aust. Vet. J.*, 74(5):395-397.

TURTON, J. A., LADDS, P. W., MANOLIS, S. C., WEBB, G. J. W. (1997) - Relationship of blood corticosterone, immunoglobulin and haematological values in young crocodiles (*Crocodylus porosus*) to water temperature, clutch of origin and body weight. *Aust. Vet. J.*, 75(2): 114-119.

TURTON, J.A., P.W. LADDS, S.C. MANOLIS, AND G. WEBB. (1994) - The influence of water temperature and clutch of origin on stress in farmed *Crocodylus porosus* hatchlings. *CSG Proceedings, Pattaya, Thailand, 2-6 May 1994. Crocodile Specialist Group*. 2: 64.

VAN JAARSVELDT, KEVIN (1990) - The trade in other exotics: their effect on the crocodilian market: ostrich and elephant. *Crocodiles: Proceedings of the 10th Working Meeting of the Crocodile Specialist Group, IUCN*, Vol. 2. p. 332-333.

VAN JAARSVELDT, KEVIN (1987) - Flaying, curing and measuring crocodile skins. *Wildlife Management: Crocodiles and Alligators*. Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead, editors., p. 387-392.

VENKATESWARALU, T., BOLANATH, T., SANYAL, D.P. (1971) A record of the gharial *Gavialis gangeticus* (Gmelin) for Patna (Bihar). *J. Bombay nat. Hist. Soc.* 68(3): 837-838.

VENKATESWARALU, T. (1974) - The gharial. *Cheetal.* 16(4): 9-11.

VIJAYA, J. (1980) - Crocodile rearing project at Sathanur. *Hamadryad*. 6(2): 3-4.

VILLALBA-MACIAS, JUAN S. (1989) - Illegal trade in crocodilian skins. *IUCN (Int. Union Conserv. Nat. Nat. Resour.) Publ. New Ser.*, p. 204.

VOS, ANTOON DE (1982) - An Evaluation of the UNDP / FAO

crocodile breeding and management project in India.—FAO, File no.8: Rome,

VYAS, R. (1994) - Mugger crocodiles in the vicinity of human settlements in south Gujarat. *Hamadryad*. 19: 94-96.

VYAS, R. (1993) - Recent cases of man-eating by the mugger (*Crocodylus palustris*) in Gujarat state. *Hamadryad*. 18: 48-49.

WAITIALGHAM, S. (1980) - Notes on the breeding of *Crocodylus palustris*. *Proc. zool. Soc. Lond.* P.180-187.

WALLIS, BRYAN E. (undated) - Marketing Assistance Programme for Agricultural products from least developed countries market prospects for Reptile leathers. *Report on a mission*. P. 1-55.

WARWICK, CLIFFORD (1990) - Crocodilian slaughter methods, with special reference to spinal cord severance. *Tex. J. Sci.*, 42(2):191-198.

WATANABE, M. E. (1982) - Suggestions for standardization of data collection techniques and terminology used in studying crocodilian nesting. *Proc. 5th Working Meet., IUCN Crocodile Specialist Group, Gainesville, FL, August, 1980*. pp. 404-409.

WATSON, JIM (1996) - Charisma! *Int. Wildl.*, 26(1):20-39.

WEBB, G. (1984) - A look at the freshwater crocodile. *Vertebrate Zoogeography and Evolution in Australasia*. Michael Archer and Georgina Clayton, editors., p. 395-400.

WEBB, G.J.W. (1979) - Comparative cardiac anatomy of the reptilia. III. The heart of crocodilians and an hypothesis on the completion of the interventricular septum of crocodilians and birds. *J. Morphol.*, 161(2): 221-240.

WEBB, G.J.W. and A.M.A. SMITH (1987) - Life history parameters, population dynamics and the management of crocodilians. *Wildlife Management: Crocodiles and Alligators*. Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead, editors., p. 199-210.

EBB, G.J.W., A.M. BEAL, S.C. MANOLIS and K.E. DEMPSEY (1987) - The effects of incubation temperature on sex determination and embryonic development rate in *Crocodylus johnstoni* and *C. porosus*. In: Webb, G., C. Manolis, and P. Whitehead (Eds.). *Wildlife Management: Crocodiles and Alligators*. Surrey Beatty and Sons, Chipping Norton, NSW, Australia. pp. 507-531.

WEBB, G.J.W. and H. COOPER-PRESTON (1989) - Effects of incubation temperature on crocodiles and the evolution of reptilian oviparity. *Am. Zool.*, 29(3):953-971.

WEBB, G.J.W. and H. MESSEL (1977) - Crocodile capture techniques. *J. Wildl. Manage.*, 41(3): 572-575.

WEBB, G.J.W., G.J. HOLLIS and S.C. MANOLIS (1991) - Feeding, growth, and food conversion rates of wild juvenile saltwater crocodiles (*Crocodylus porosus*). *J. Herpetol.*, 25(4): 462-473.

WEBB, G.J.W. and S.C. MANOLIS (1987) - Methods for retrieving crocodilian embryos. *Wildlife Management: Crocodiles and Alligators*. Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead, editors., p. 423-426.

WEBB, G.J.W., S.C. MANOLIS, K.E. DEMPSEY and P.J. WHITEHEAD (1987) - Crocodilian eggs: a functional overview. *Wildlife Management: Crocodiles and Alligators*. Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead, editors., p. 417-422.

WEBB, G.J.W., S.C. MANOLIS and G.C. SACK (1984) - Cloacal sexing of hatchling crocodiles. *Aust. Wildl. Res.*, 11(1): 201-202.

WEBB, G.J.W., S.C. MANOLIS, K.E. DEMPSEY and P.J. WHITEHEAD (1987) - Crocodilian eggs: A functional overview. In: Webb, G., C. Manolis, and P. Whitehead (Eds.). *Wildlife Management: Crocodiles and Alligators*. Surrey Beatty and Sons, Chipping Norton, NSW, Australia. pp. 417-422.

WEBB, G.J.W., R. BUCKWORTH, G.C. SACK and S.C. MANOLIS. (1983) - An interim method for estimating the age of *Crocodylus porosus* embryos. *Aust. Wildl. Res.* 10: 563-570.

WELDON, PAUL J. AND MICHAEL J. TANNER (1991) - Gular and paracloacal gland secretions of crocodilians: a comparative analysis by thin-layer chromatography. *Biochem. Syst. Ecol.*, 19(2):133-141.

WELLS, R. M. G., L. A. BEARD AND G. C. GRIGG (1991) - Blood viscosity and hematocrit in the estuarine crocodile, *Crocodylus porosus*. *Comp. Biochem. Physiol. A Comp. Physiol.*, 99(3): 411-414.

WERMUTH, H., MERTENS, R. (1961) - Schildkroten, krokodile, bruckenechsen. *Veb. Guster fisher verlag, jena*. 1961. P.

WERMUTH, H. (1953) - Systematik der rezenten krokodile. *Mitteil Zool. Mus. Berlin*. 29(2): 375-524.

WERMUTH. (1964) - Das verhaltnis zwischen kopf, pumpf-und

schwanzelange bei den rezenten krokodilen. *Senckenberg biol.* 45: 369-385.

WERNER, F.(1933) - Reptilia, loricata das tierreich. *Gruyter and Co.*, Berlin.

WESSELLS, NORMAN K. (1980) - Vertebrates : Adaptation / Norman K. Wessells.— San Francisco: W.H. Freeman and Co., vi,256p.

WHETSTONE, K. N. AND MARTIN, L. D. (1979) - New look at the origin of birds and crocodiles. *Nature*, 279 (5710): 234-236. 17 May 1979.

WHETSTONE, K.N. AND L.D. MARTIN. (1981) - Common ancestry for birds and crocodiles? A reply. *Nature*. 289: 97-98.

WHITAKER, N. and H. ANDREWS (1998) - Madras croc bank, an update. In *Proceedings of 14th Working Meeting of CSG, 13-17th July, 1998, Singapore*. P.402-406.

WHITAKER, R. (1975) - Status and conservation of the gharial *Gavialis gangeticus*. *Hepetal. Rev.* 4. (1). P.2-3.

WHITAKER, R. (1976) - A note on crocodilian sex determination. *J. Bombay nat. Hist. Soc.*, 73(3):531-532.

WHITAKER, R. (1978) - Note on the status of the gir crocodiles. *J. Bombay nat. Hist. Soc.*, 75 (1): 224-227.

WHITAKER, R. (1978) - Permanent marking systems for crocodilians. *J. Bombay nat. Hist. Soc.*, 75(2):496.

WHITAKER, R. (1978) - Gharial wald. *Hamadryad*. 3(1): 5.

WHITAKER, R. (1979) - The madras snake part: its role in public education and reptile research. *Int. zoo Yrbk.* 19: 31-38.

WHITAKER, R. (1979) - Future of crocodiles in Tamil Nadu. *Indian For.*, 105(8):592-593.

WHITAKER, R. (1980) - Value of crocodiles. *Indian Forester*. 106(3): 223.

WHITAKER, R. (1981) - Optimum growth rates of captive mugger (*Crocodylus palustris*) at Madras Crocodile Bank. *Indian Forester*. 107(2): 102-103.

WHITAKER, R. (1981) - Sex ratios in clutches of captive bred mugger. *Hamadryad*. 6(2): 7.

WHITAKER, R. (1982) - Review of crocodile management options and practices in Asia. *Crocodiles: Proceedings of the Fifth Working Meeting of the IUCN/SSC Crocodile Specialist Group*. David Dietz, F. Wayne King, and Rhoda J. Bryant, editors., p. 337-341.

WHITAKER, R. (1982) - Status of asian crocodilians. *Crocodiles: Proceedings of the Fifth Working Meeting of the IUCN/SSC Crocodile Specialist Group*. David Dietz, F. Wayne King, and Rhoda J. Bryant, editors., p. 237-266. 1982.

WHITAKER, R. (1984) - Captive breeding of crocodiles in India. *Acta Zool. and J. Pathol. Ant.* Vol. V pp. 309-318. In: *Maintenance and reproduction of reptiles in captivity*. Ed. by Bels V. L. and Sande, A.P..

WHITAKER, R. (1987) - The management of crocodilians in India. In: Webb, G., C. Manolis, and P. Whitehead (Eds.). *Wildlife Management: Crocodiles and Alligators*. Surrey Beatty and Sons, Chipping Norton, NSW, Australia. pp. 63-72.

WHITAKER, R. (1991) - Mugger in a factory lake in Goa. *Hamadryad*. 16(1-2): 38.

WHITAKER, R. (1996) - Madras Croc Bank. *Crocodile Spec. Group NewsL*, 15(3):7-8.

WHITAKER, R., C. HARTONO AND P. SUKRAM (1986) - Croco-

dile farming prospects in Irian Jaya WWF project 1528. *Tigerpaper*, 13(2):19-20.

WHITAKER, R. and D. BASU (1983) - The gharial (*Gavialis gangeticus*): A review. *J. Bombay nat. Hist. Soc.* 79(3): 531-548.

WHITAKER, R., D. BASU and C.A. ROSS (1979) - Gharial survey and observations on the Ramganga River, Corbett National Park, U.P. *Hamadryad*. Supplement no 2.: 1-17.

WHITAKER, R. and J.C. DANIEL (1978) - The status of Asian crocodilians. *Tiger Paper (FAO, Asia)*. 5(4): 12-17.

WHITAKER, R. AND J. C. DANIEL (1980) - The status of Indian crocodilians. *J. Bombay nat. Hist. Soc.*, 75(suppl.):1238-1245.

WHITAKER, R. and H. ANDREWS (1988) - Notes on crocodilian locomotion. *J. Bombay nat. Hist. Soc.* 85(3): 621-622.

WHITAKER, R. and H. ANDREWS (1989) - Chemical immobilization of the mugger crocodile (*Crocodylus palustris*) with gallamine triethiodide. *Indian Forester*. 115(5): 355-356.

WHITAKER, R. and H. ANDREWS (1989) - First record of a skin nematode on an Indian mugger crocodile (*Crocodylus palustris*). *J. Bombay nat. Hist. Soc.* 86(1): 106.

WHITAKER, R. AND H. ANDREWS (1995) - Tamil Nadu crocodile situation set straight. *Croc. Spec. Group NewsL*, 14(4):7.

WHITAKER, R., V.C. RAJAMANI, D. BASU and V. BALAKRISHNAN (1974) - Preliminary survey of the gharial, *Gavialis gangeticus*. *Madras Snake Park Trust Report*. 1974: 1-16.

WHITAKER, R. AND Z. WHITAKER (1975) - Collection and hatching of Marsh crocodile (*C.*

palustris) eggs.—*J. Bombay nat. Hist. Soc.*: 73: 2, 1975. P. 404-407.

WHITAKER, R. AND Z. WHITAKER (1976) - Collection and hatching of marsh crocodile (*Crocodylus palustris*). *J. Bombay nat. Hist. Soc.* 73(2): .403-7.

WHITAKER, R. AND Z. WHITAKER (1977) - Notes on natural history of *Crocodylus palustris*. *J. Bombay nat. Hist. Soc.* 74(2): 358-360.

WHITAKER, R. AND Z. WHITAKER (1977) - Notes on vocalization and protective behaviour in the Mugger.—*J. Bombay nat. Hist. Soc.*: 75(1): 227-228.

WHITAKER, R. AND Z. WHITAKER (1978) - A preliminary survey of the saltwater crocodile (*Crocodylus porosus*) in the Andaman islands. *J. Bombay nat. Hist. Soc.*, 75 (1): 43-49.

WHITAKER, R. AND Z. WHITAKER (1978) - Growth rate of *Crocodylus palustris*. *J. Bombay nat. Hist. Soc.* 75(1): 231-232.

WHITAKER, R. AND Z. WHITAKER (1978) - Notes on captive breeding in mugger *Crocodylus palustris*. *J. Bombay nat. Hist. Soc.* 75(1): 228-231.

WHITAKER, R. AND Z. WHITAKER (1979) - The food of captive crocodilians. *Indian Forester*, 105(12): 886-887.

WHITAKER, R. AND Z. WHITAKER (1980) - Mugger breeding at the Madras Crocodile Bank. *Makara*. 2(1): 17.

WHITAKER, R. and Z. WHITAKER (1984) - Reproductive biology of the mugger (*Crocodylus palustris*). *J. Bombay nat. Hist. Soc.* 81: 297-317.

WHITAKER, R. AND Z. WHITAKER (1989) - Ecology of the mugger crocodile. *IUCN (Int. Union Conserv. Nat. Nat. Resour.) Publ. New Ser.*, p. 276-296.

WHITAKER, R. AND Z. WHITAKER (1989) - Status and conservation of the Asian crocodilians. *IUCN (Int. Union Conserv. Nat. Nat. Resour.) Publ. New Ser.*, p. 297-308.

WHITAKER, R. AND Z. WHITAKER (1991) - Ecology and management of the mugger crocodile in India. *First national symposium on unconventional pests : control vs conservation and National seminar on animal behaviour Oct. 14-16, 91, 1991*. P. 45-61.

HITAKER, R., Z. WHITAKER and A. VAUGHAN (1980) - Notes on sexing crocodilians. *J. Bombay nat. Hist. Soc.* 77(2): 341-343.

WHITAKER, Z. (1978) - Gharial walk. *Hamadryad*. 3(1): 5.

WHITAKER, Z. (1981) - The crocodile project in Andhra Pradesh. *Hamadryad*. 6(2): 12-13.

WHITAKER, Z. (1994) - I married a croc man. *International Wildlife*. 24: 34-37.

WHITAKER, Z. AND R. WHITAKER (1981) - Crocodiles, a chink in their armour may be? *The India magazine 1981*. P.34-41.

WHITEHEAD, PETER J. AND SEYMOUR, ROGER S. (1990) - Patterns of Metabolic rate in Embryonic Crocodilians *Crocodylus Johnstonei* and *Crocodylus porosus*. *Physiological Zoology*: 63(2): 334-352.

WILDLIFE WEALTH OF INDIA(1986) - Resources and management / edited by Trilok Chandra Majupuria.— Thailand: Tecpress service, 1986. 656p.

WILDLIFE MANAGEMENT (1987) - Crocodiles and Alligators / edited by Grahame J.W. Webb, S. Charlie Manolis and Peter J. Whitehead. Australia: Surrey Beatty and Sons, 1987. 552p.

WILKINSON, H. (1883) - Sunny lands and seas. *John Murray, London*. 1883. P.

WILLIAMS, JOHN T., JR. AND BERNARD A. ALBINIAK, JR. (1972) - Probability learning in a crocodilian. *Psychonomic Sci. Sect. Anim. Physiol. Psychol.*, 27(3):165-166. 1972. From *Biol. Abstr.* 54(12), 1972.

WOODWARD, D. E. AND J. D. MURRAY (1993) - On the effect of temperature-dependent sex determination on sex ratio and survivorship in crocodilians. *Proc. R. Soc. Lond. B Biol. Sci.*, 252(1334):149-155.

WRIGHT, D. E. AND L. A. MOFFAT (1985) - Morphology and ultrastructure of the chin and cloacal glands of juvenile *crocodylus porosus* (reptilia, crocodilia). *Biology of Australasian Frogs and Reptiles*. Gordon Grigg, Richard Shine, and Harry Ehmann, editors., p. 411-422.

WRIGHT, J. C. (1985) - Oxygen consumption during voluntary undisturbed diving in the saltwater crocodile, *Crocodylus porosus*. In: *Biology of Australasian Frogs and Reptiles*. Gordon Grigg, Richard Shine, and Harry Ehmann, editors., p. 423-429.

WRIGHT, JONATHAN C. (1987) - Energy metabolism during unrestrained submergence in the saltwater crocodile *Crocodylus porosus*. *Physiol. Zool.*, 60(5): 515-523.

WRIGHT, J.C. AND D. KIRSHNER. (1987) - Allometry of lung volume during voluntary submergence in the saltwater crocodile *Crocodylus porosus*. *The Journal of Experimental Biology*. 130: 433-436.

WRIGHT, J.C., G.C. GRIGG, AND C.E. FRANKLIN. (1992) - Redistribution of air within the lungs may po-

tentiate "fright" bradycardia in submerged crocodiles (*Crocodylus porosus*). Comparative Biochemistry and Physiology. Comparative Physiology. 102(1): 33-36

YADAV, R.N. (1969) - Breeding mugger crocodile *Crocodylus palustris* at Jaipur zoo. Int. Zoo Yrbk. 9: 33.

YADAV, R.N. (1979) - A further reports on breeding the mugger crocodile *Crocodylus palustris* at Jaipur zoo. Int. Zoo. Yrbk. 19: 66-68.

YAMANAKA, TOSHIO (1990) - The trade in other exotics: their ef-

fect on the crocodilian market: lizard, snake, and shark. Crocodiles: Proceedings of the 10th Working Meeting of the Crocodile Specialist Group, IUCN., Vol. 2. p. 330-331. 1990.

ZOBAIRI, A.R.K. (1948) - The use of the bark of *Strychnos nuxvomica* Linn. in poisoning a crocodile. J. Bombay nat. Hist. Soc. 47(4): 707-709.

ZSI Fauna of Corbett National Park / edited by B.S. Lamba.— Calcutta: Zoological survey of India, 1987. 86p. (Fauna of Conservation Areas, 2).

ZSI Ecology of Animal Population : Part 4 Proceedings of the Symposium on Ecology of Animal Population From 26th Oct. to 28th Oct., 1978 / Zoological Survey of India.— Calcutta: ZSI, 1982. 188p.

ZUG, GEORGE R. (1974) - Crocodilian galloping: An unique gait for reptiles. Copeia. 1974(2): 550-552.

ZWINENBERG, A.J. (1978) - Biologie en status van de ganges gavial *Gavialis gangeticus*. Lacerta. 36(8): 136-142.

List of Contributors

AJAI SAXENA Scientist SF (Wildlife Management) Wildlife Institute of India Dehra Dun	KGM PILLAI Dy Director (Wildlife Education) Kerala Forest Department Trivandrum (Kerala)
ASHOK SINGH 5 Clive Road Allahabad 211 01	KK SHARMA Forest Range Officer Rajasthan Forest Department
BR RAWAL Asstt Director GEER Foundation, Indroda Park Sector 9 Gandhinagar 382 009 (Gujarat)	K VARA PRASAD Asstt Conservator of Forests AP Forest Department
B SRINIVAS Asstt Conservator of Forests Andhra Pradesh Forest Department	LAK SINGH C/o Office of the CF (Forests) Simlipal Tiger Reserve Post Bhanjapur Baripada 757 002 (Orissa)
DAULAT SINGH Forest Range Officer Rajasthan Forest Department	LN ACHARJYO M -71 Housing Board Colony Baramunda Bhubaneshwar 751 003 (Orissa)
D BASU Gharial Rehabilitation Centre Kukrail Lucknow 226 022 (Uttar Pradesh)	MG GOGATE Chief Wildlife Warden Maharashtra Forest Dept. Nagpur (Maharashtra)
HARRY V ANDREWS Centre for Herpetology Madras Crocodile Bank Trust Post Bag 4 Mamallapuram 603 104 (Tamil Nadu)	PK CHOUDHURY Panna National Park Panna (Madhya Pradesh)
H ROBERT BUSTARD Airlie Brae, Alyth Perthshire PH11 8AX Scotland	RAJU VYAS Sayali Baug Zoo Vadodara (Gujarat)

Contd.

RAM LAKHAN SINGH
Wild Life Preservation
Organization
UP Forest Department
Lucknow (Uttar Pradesh)

RK SHARMA
National Chambal Sanctuary
PO Box 29
Morena 476 001
(Madhya Pradesh)

RJ RAO (Honorary Wildlife Warden)
School of Studies in Zoology
Jiwaji University
Gwalior 474 001 (Madhya Pradesh)

ROM WHITAKER
Centre for Herpetology
Madras Crocodile Bank Trust
Post Bag 4
Mamallapuram 603 104
(Tamil Nadu)

SK KAR
Research Officer (Wildlife)
O/o Chief Wildlife Warden
7 Saheednagar
Bhubaneshwar 751 007
(Orissa)

SK PATNAIK
Chief Wildlife Warden (Orissa)
7 Saheednagar
Bhubaneshwar 751 007
(Orissa)

SUBRATO PAL CHOWDHARY
Technical Assistant (Wildlife)
Forest Department
West Bengal

TIRTHA M MASKEY
Director General
Department of National Parks and
Wildlife Conservation
Kathmandu
Nepal

V VIJAYA KUMAR
Patwadi Naka
Gujarat Institute of Desert Ecology
Bhuj
Kachchh 370 001 (Gujarat)

Guest Editor
BC CHOUDHURY
Scientist SF
Wildlife Institute of India
Dehra Dun

Notes

OTHER ENVIS CENTRES

* *Control of Pollution (Water, Air and Noise)*

Central Pollution Control Board

Parivesh Bhawan, East Arjun Nagar
Delhi 110 092

Tel : 011-2217213

Telex : 031-66440 PCON IN

Grams : CLEENVIRON; Fax : 011-2217078,
Email : cpcb@envfor.delhi.nic.in;
URL : <http://www.nic.in/envfor/cpcb>

* *Toxic Chemicals*

Industrial Toxicological Research Centre

Mahatma Gandhi Road, Lucknow 226 001
Tel : 0522-213175;

Grams : INTOXI LUCKNOW

Telex : 0535-2456; Fax : 0522-228227

Email : intox@itrc.sirnet.ernet.in;

* *Appropriate and Environmentally Sound Technology*

Development Alternatives

B-32 Institutional Area, Tara Crescent,
New Mehrauli Raod, New Delhi 110 016

Tel : 011-6967938; Fax : 011-6866031

Email : tara@sdalt.ernet.in

* *Biodegradation of Wastes and Environmental Impact Assessment*

Centre for Environment Studies

College of Engineering, Anna University,
Chennai 600 025

Tel : 044-2351723/Extn 3192;

Gram : ANNATECH MADRAS

Fax : 044-2350397;

Email : envismas@envismas.ernet.in

* *Renewable Energy and Environment*

Tata Energy Research Institute (TERI)

Darbari Seth Blk, Habitat Place, Lodi Road
New Delhi 110 003

Tel : 011-4622246; Grams : TERINST;

Fax : 080-4621770, 4632609;

Email: mailbox@teri.ernet.in

* *Western Ghats and Biological Diversity*

Centre for Ecological Science

Bangalore 560 012

Tel : 080-3340985, 3344411/Extn 2506;

Fax : 080-3341683

E-mail: rag@ces.iisc.ernet.in;

URL : <http://ces.iisc.ernet.in/hpg/envis>

* *Non-Government Organizations, Media and Parliament Matter Related to Environment*

World Wide Fund for Nature - India

172-B, Lodi Estate, Max Mueller Marg
New Delhi 110 003

Tel: 011-4627586;

Grams: PANDAFUND, DELHI

Fax: 011-4626837

* *Environmental Management Related to the State of Madhya Pradesh*

Environmental Planning & Coordination Organisation

E-5 Sector, Arera Colony, Bhopal 462 016
Tel : 0755-565868; Fax : 0755-562136

* *Occupational Health*

National Institute of Occupational Health

Meghani Nagar, Ahmedabad 380 016
Tel : 079-7867351; Grams : NIOHEALTH
Fax : 079-7866630

* *Desertification*

Central Arid Zone Research Institute (CAZRI)

Jodhpur 342 002
Tel : 0291-40931; Fax: 0291-40706
Email : cazri@x400.nicgw.nic.in

* *Mangroves, Estuaries, Lagoons and Coral Reefs*

Centre for Advanced Studies in Marine Biology

Annamalai University
Parangipettai 608 502
Tel : 04144-83533; Fax : 04144-83555

* *Environmental Education*

Centre for Environment Education

Thaltej Tekra, Ahmedabad 380 054.
Tel : 079-6442642; Fax : 079-6420242
E-Mail : cee@ad1.vsnl.net.in

* *Faunal Biodiversity*

Zoological Survey of India

M-Block, New Alipore, Calcutta 700 053
Tel : 033-4786893

Grams : ZOOLOGY,CALCUTTA
Fax : 033-4786893
URL : <http://www.nic.in/envfor/zsi>

* *Environmental Problems of Mining*

Centre of Mining and Environment

Indian Schools of Mines, Dhanbad 826 004
Tel: 0326-206372; Fax: 0326-206372
Email : cme@ismine.ernet.in

URL : <http://www.nic.in/envfor/cme>

* *Solids Wastes including Hazardous Waste*

National Environmental Engineering Research Institute (NEERI)

Nehru Marg, Nagpur 440 020
Tel : 0712-226071; Grams : NEERI
Fax : 0712-222725

* *Himalayan Ecology,*

GB Pant Institute of Himalayan Environment & Development

Kosi-Katarmal 263 643
Tel : 05962-41014;
Fax : 05962-30100 Attn. GBPHED
Email : ghpihed@shakti.ncst.ernet.in
URL : <http://www.nic.in/envfor/gbpihed>

* *Human Settlement*

School of Planning and Architecture

Indraprastha Estate
New Delhi 110 002
Tel : 011-3318353; Fax : 011-3319435
Email : akm@spa.ernet.in

* *Biogeochemistry and Environmental Law*

School of Environmental Sciences

Jawaharlal Nehru University
New Delhi 110 002
Tel : 011-6106501/Extn. 429
Fax : 011-6165886; Grams : JAYENU
Email : subra@jnuv.ernet.in

* *Flora Biodiversity*

Botanical Survey of India

P-8, Barbourne Road
Calcutta 700 001
Tel : 033-2424922; Fax : 033-2429330
Grams : BOTSURVEY
Email : envis.bsi@gems.vsnl.net.in
URL : <http://www.nic.in/envfor/bsi>

* *Eastern Ghats*

Environmental Protection Training and Research Institute

2nd Floor, Maitrivanam, Huda Complex
SR Nagar, Hyderabad 500 038
Tel : 040-291366; Fax : 040-291366
Email : chat@eptri.stph.net.in

* *Avian Ecology including Inland Wetlands*

Bombay Natural History Society (BNHS)

Hornbill House, Dr. Salim Ali Chowk

Shaheed Bhagat Singh Road,

Mumbai 400 023

Tel : 022-2821811; Fax: 022-2837615

Grams : HORNBILL

Email: envis@bnhs.wiprobt.ems.vsnl.net.in

* *Forestry*

Forest Research Institute

PO New Forests, Dehra Dun 248 006
Tel : 0135-626865

Email : icfre_mis@x400.nicgw.nic.in

URL : <http://www.nic.in/envfor/icfre>

* *Panchayat Raj and Environment*

Indian Environmental Society

U-112, Vidatha House, Vikas Marg
Shakarpur, Delhi 110 092
Tel : 011-2223311; Fax : 011-3317301
Email : iesnro@del2.vsnl.net.in

* *Communication and Electronic Media*

Centre for Media Studies
9/1, Institutional Area,
New Delhi-110067
Tel : 011-6851660, 6864020,
Fax : 91-11-6968282,
Email : nbracems@giasdlo1.vsnl.net.in

Wildlife Institute of India
Post Box 18, Chandrabani
Dehra Dun 248 001
Tel - 0135 - 640112-115
Fax - 0135 - 640117
Email - envis@wii.gov.in